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Transactions of the

ACADEMY *of* SCIENCE

of Saint Louis

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VOLUME XXXI, No. 1

FRONTIER AGRICULTURE in NORTHERN MINNESOTA

George F. Brightman
University of Minnesota

Issued May 31, 1942

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FRONTIER AGRICULTURE IN NORTHERN MINNESOTA*

In spite of the oft-repeated laments of historians and economists for America's "vanished frontier," the United States still has many areas of pioneer settlement, as Bowman has pointed out.[1] One of these present-day frontiers extends across northern Minnesota. It is a broad zone of experimental settlement, lying near the edge of the cut-over coniferous forest. To the west and south are the well-populated farm lands of the Red River valley and southern Minnesota; to the northeast settlement frays out into the almost unpopulated wilderness which stretches northward from Lake Superior to Hudson Bay.

Athwart this frontier zone, in north central Minnesota, lies the Brainerd Community, the section with which this paper will deal (Fig. 1). This nearly rectangular area, of some 2,500 square miles, is not a "natural" or cultural region; instead its boundaries follow economic divides, the shopping area tributary to Brainerd, a city of 12,000 population, from which the area takes its name. So far as agriculture is concerned, these boundaries are arbitrary, but the area is a convenient unit for the examination of farming in the cut-over lands, since it includes both fairly well peopled districts, and sections of unpopulated wilderness, as well as the gradations between these two extremes.

Agricultural settlement in this part of Minnesota is, by Middle Western standards, recent. As early as 1850 lumbermen had begun to invade the forests, and in 1870, when the Northern

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* This paper is based, in part, upon work done while the writer held a Field Fellowship of the Social Science Research Council, in 1939-1940.

[1] Isaiah Bowman, "Jordan Country," *Geog. Rev.*, vol. 21, pp. 22-55, 1931.

FIGURE 1

Index map showing the location of the Brainerd Community (shaded) within Minnesota, and its situation relative to the boundary of the northern coniferous forest. This boundary is after maps by H. S. Ayres (21st Ann. Rept. U.S.G.S., Part V, Pl. 53) and C. S. Sargent (Report on the Forests of North America, Tenth Census of U. S. 1880, vol. 9).

Pacific Railroad, reaching out westward from the head of the Lakes at Duluth, was built across the area, a number of flourishing lumber and railroad towns sprang up along its route. The westward sweep of the frontier across Minnesota and out onto the plains failed to bring farmers into the coniferous forests, however, and it was not until about 1890, when the sub-humid lands of the west offered the only alternative, that land-seekers began to trickle into the cut-over country. Settlement was most active in the decades 1890-1900 and 1910-1920, but increased sharply again between 1930 and 1940, as a result of the economic depression. Between 1900 and 1920 it was encouraged by land and colonization companies, formed to dispose of vast blocks of cut-over land acquired from lumbermen, who actively publicized the Brainerd Community, and northern Minnesota generally, in glowing terms as the "last frontier," the last area where cheap land could be had virtually for the asking, and a man could make himself a farm by his unaided labor.

The environmental conditions which had been responsible for the long avoidance of this country by landseekers still remained, however, and they continue today to limit the possibility of agricultural selttlement.

Much of the land is nearly worthless for farming purposes. This is an area where the landforms and soil-materials are a heritage of the last continental glaciation, with all that this implies. There are terminal moraines with oversteep slopes and stony soils; there are flat, droughty, sandy outwash plains, and there are many swamps.

It is not easy to transform the wild land into a farm. The best soils are those which have supported white and Norway pine forests. These forests have been almost entirely cut over, but the great stumps, extremely slow to decay, remain, usually surrounded by dense stands of second-growth aspen and jack pine. Lumbering did not deforest the region, although it radically altered the character and value of the forests. After the stumps have been pulled and the field brushed, stones must usually be

removed, and the settler soon discovers that each year a new "crop" of stones will come to the surface.

Moreover, even after the settler has laboriously transformed his tract of wild land into a farm, he is still not free of handicaps. The soils are forest types, acid, deeply leached, and low in humus. The climate also has its limitations. Winters are long and cold, and the average length of the frost-free season is only 124 days, which means that, in many years, corn cannot be matured. Small grains may be grown, but yields are less than in more southerly locations. The soils and climate are least unfavorable for the raising of potatoes and hay crops, but potatoes are the only crop which shows higher yields in the cut-over country than in other parts of Minnesota.[2]

In spite of these scarcely attractive conditions, there are today some 3,272 farms in the community; the total acreage "in farms" is 475,129, an average of 145 acres per farm.[3] In the whole area, land in farms occupies a trifle more than one-fourth of the land surface. But these averages mean very little. A better notion of the extent of agricultural settlement may be obtained from the dot map (Fig. 2) on which the dots are drawn true to scale so that the area they actually cover is the acreage they represent. The map shows a few areas of nearly solid black, where much of the surface is in farms, and a rather large area where there is almost no settlement, as well as some sections of intermediate density.

The meaning of this pattern cannot be grasped without a more concrete notion of the character of farming in the area than can be gained from a dot map of acreage in farms. The

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[2] S. A. Engene and G. A. Pond, *Agricultural Production and Types of Farming in Minnesota*, Univ. of Minn. Agric. Exp. Sta. Bull. 347, Statistical Supplement, 1940.

[3] These figures are averages of the five years 1936 through 1940, prepared by the writer from manuscript returns of the Minnesota State Farm Census. This census is taken annually, on a township basis, by local assessors, under Federal supervision. Unless otherwise identified, agricultural statistics in this paper are 1936-1940 averages, from this source.

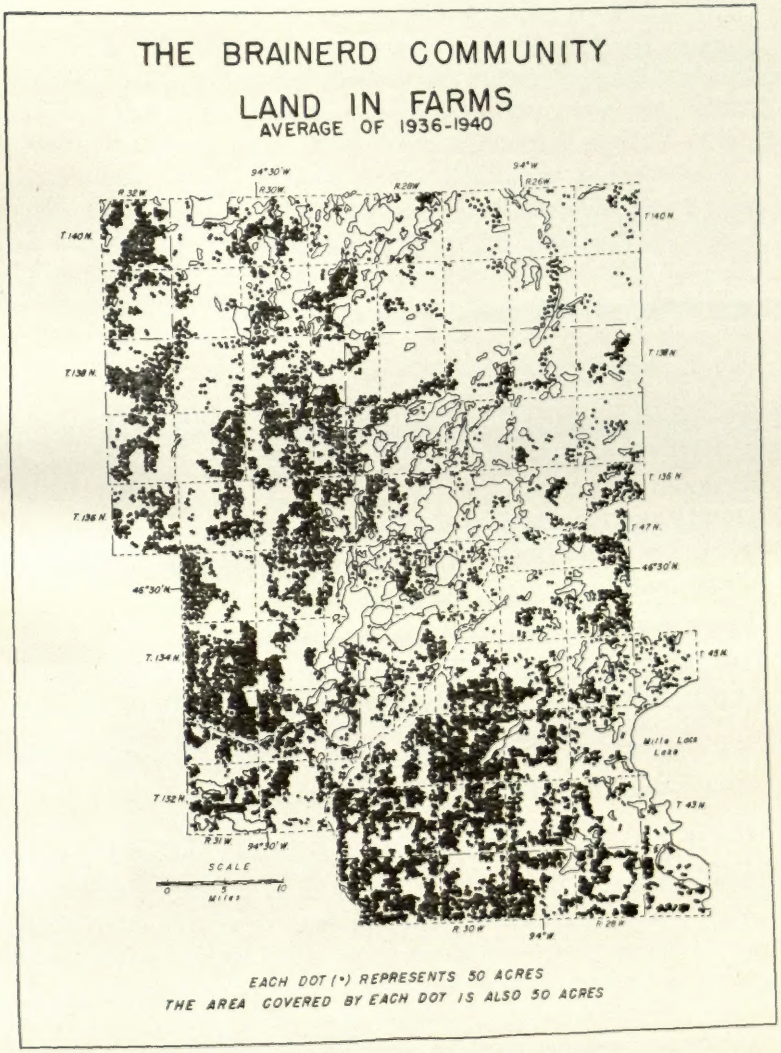

FIGURE 2

Acreage of land "in farms" (average of 1936-1940)

farms of the community fall, in general, into two major categories. The first of these comprises what might be called "maturely-developed" farms. A normal farm of this sort occupies about 160 acres, but of this only a relatively small amount, about 50 acres, is in crops. Some 80 acres is used for pasture — either woodland or partially cleared land, on which stumps, rocks, and brush still remain. Almost none of the pasture is on land which has ever been cultivated. There is likely to be some marshy land on which wild hay is cut — perhaps 10 or 20 acres, although this varies greatly from farm to farm. The remainder of the acreage is wild land, usually covered with scrub forest, from which some firewood is obtained.

The leading crop on these farms is hay, usually a mixture of timothy, red clover, and alsike, which are well adapted to the climate and the acid soils. Alfalfa is less common. Hay crops occupy something over a third of the crop land. The remaining plowland is normally divided nearly equally between corn and various small grains. Corn cannot be depended on to mature in this climate, and most of it is cut green, and made into silage. Of the small grains, oats are grown in greatest amount, with barley a poor second. There may be a few acres of wheat, buckwheat, or flax, and on some farms, where the soil is very sandy, rye is the chief small grain. There is likely to be an acre or two of potatoes, but rarely more than that on any one farm.

The normal system of crop rotation is to plant a field in small grain the year after it has been used for corn. Hay is sown with the grain, which serves as a nurse crop, and during the following year, sometimes two years, the field remains in hay, after which it is plowed and planted in corn. Only rarely does use of the field for pasture enter into the rotation; there is too much land suitable only for pasture, and too little cropland to permit this.

It will be observed that the typical maturely-developed farm which is being described is organized for the production of forage and fodder for livestock, doubtless because these are the

FIGURE 3

Farmstead of a typical maturely-developed farm in sec. 36, T. 138 N., R. 28 W. Note the disparity in quality between the house (extreme right) and the barn. The pasture lot in the foreground is not unusually stony.

crops least unsuited to the climate and soils. The livestock which consume these products are dairy cattle; every normal farm has its herd of ten or so cows. There may be a few hogs, and exceptionally, some sheep. The concentration on dairying, and the neglect of other types of livestock farming, reflects the type of feed crops which can be grown. Fattening beef cattle (and hogs) requires a rather high percentage of concentrates — corn and small grains — in the feed, but dairy cattle can use a greater amount of roughage, i. e., hay, corn silage, and corn fodder. Since the community does not produce an adequate amount of concentrates even for its dairy herds, and must import corn and other grains for feed, fattening beef cattle is out of the question. Dairy cattle also require a good deal more labor than most livestock; this profitable employment for the farmer is advantageous on these farms, with their small acreage of cropland.

Since there is only a small market for fresh milk, and since no cheese is made, the chief source of income on the normal farm is from the sale of cream, which is manufactured into butter at one of the several creameries scattered throughout the community. The butter is sold, for the most part, in eastern markets.

Many of the maturely-developed farms are attractive and even prosperous-looking. The farmstead is always dominated by a great barn, often well built and well painted, with a tower-like silo at the end. The farmhouse itself is likely to be small and even dilapidated, however — perhaps only of one story, and covered with tar paper (Fig. 3).

The second major type of farm in the community is less easily generalized about than the maturely-developed type just discussed. "Primitive" is the best one-word characterization of these farms, and the term "jack-piners" which is commonly applied to their occupants, is an apt one, implying as it does a location on wild land, and wild land of a rather poor sort, to boot.

These primitive farms are smaller than the maturely-developed ones. A normal example may have 120 acres of land (al-

FIGURE 4

Stump pasture on land from which jack pine has recently been cut, in section 20, T. 139 N., R. 32 W. In the background is typical wild land.

FIGURE 5

Farmstead of a "jack-piner" in sec. 9, T. 43 N., R. 29 W. The farmhouse can hardly be distinguished from the barns. Note the haystacks; this is a dairy farm.

though 80 or even only 40 acres is not unusual). Of this 120 acres only about 20 is cleared cropland — proportionately less than half as much as on a farm of the first type. Some 60 acres is used for pasture; this is largely land still wooded or still covered with brush and stumps (Fig. 4). Wild hay is relatively more important here than on the more mature farm, and the amount of unused wild land is rather greater.

Surprisingly enough, these small and primitive farms are dairy farms, but the herd is very small — four to six cows on the average farm, but an even smaller number on many. The sale of cream, to be made into butter, is the chief source of income, which is likely to be small. On at least half of the farms of this type, the annual cash income is probably less than $200.

The buildings on the farms of the "jack-piners" are usually few and primitive. The house and barns are likely to be nearly indistinguishable from each other — small shacks, either dilapidated or rawly new, built of rough lumber and perhaps covered with building paper (Fig. 5). The whole enterprise usually wears an appearance of impermanence, and indeed abandoned farms of this sort are fairly common in the area (Fig. 6). The "jack-piners" are continually moving from farm to farm, and there is some migration both into and out of the general region.

Wild land "suitable" for this type of settlement is plentiful in the community, but, paradoxically enough, the basic reason for the poverty of the primitive type of farm is that these farms are too small. It is, of course, the acreage of cropland which is inadequate, especially for the rather extensive type of agriculture which is best suited to this area. Cut-over land may be purchased for a few dollars an acre, but clearing is both laborious and expensive. Estimates indicate that clearing an acre of land is likely to cost the farmer $35 to $60, figuring his labor at only 15 cents an hour.[4] Even if the settler is able to do the work at slack

[4] G. A. Pond and C. W. Crickman, *Planning Farm Organizations for the Northeast Cut-over Section of Minnesota,* Univ. of Minn. Agric. Exp. Sta. Bull. 295, pp. 30-31, 1933.

FIGURE 6

Abandoned farms like this one are not rare in the community. In sec. 12, T. 138 N., R. 28 W.

FIGURE 7

Open farm landscape in a densely settled section of maturely-developed farms, on gently rolling Keewatin ground moraine. In sec. 32, T. 134 N., R. 31 W.

times, the cost of clearing adds a great deal to the cost of the land. Clearing is likely to progress very slowly on a new farm, and it may take ten years or more to establish a "good" cut-over farm, with around 23 acres of cropland, which will support a half dozen cows, and furnish the settler a precarious living. To tide the pioneer farmer over the period before the farm is productive a considerable amount of capital is required — on the average about $8,000.[5]

Pioneer regions do not customarily attract farmers with much capital, and this particular area, publicized by land companies and the state as a "last frontier" drew many settlers with resources hardly adequate to buy land, much less to develop it. Consequently, most of the "jack-piners" find it necessary to eke out their income by obtaining some work outside the farm. Many of them cut pulpwood, or work on the county roads, or serve as guides at summer resorts, or in the fall find a few weeks' work harvesting wild rice from the lakes. In recent years the W. P. A. has been another source of cash income. Too much outside employment of this sort defeats its own purpose, however, by preventing the farmer from clearing more land, and developing his farm to the point where it will support him. Some of the poorest among the primitive farms are the homes of settlers forced by these circumstances (or by inclination) into becoming forest workers or casual laborers who are only very secondarily farmers.

Farms of these two rather different types — primitive and maturely-developed — are intermixed to form the intricate settlement pattern shown on the map of land in farms (Fig. 2).

As the map indicates, there are a few areas, lying, almost without exception, within the southern and western halves of the community, where a very large proportion of the land is in agricultural use. In these areas most, although not all, of the farms are of the maturely-developed type, and there is enough

[5] W. A. Hartman and J. D. Black, *Economic Aspects of Land Settlement in the Cut-over Region of the Great Lake States,* U.S.D.A. Circ. 160, p. 62, 1931.

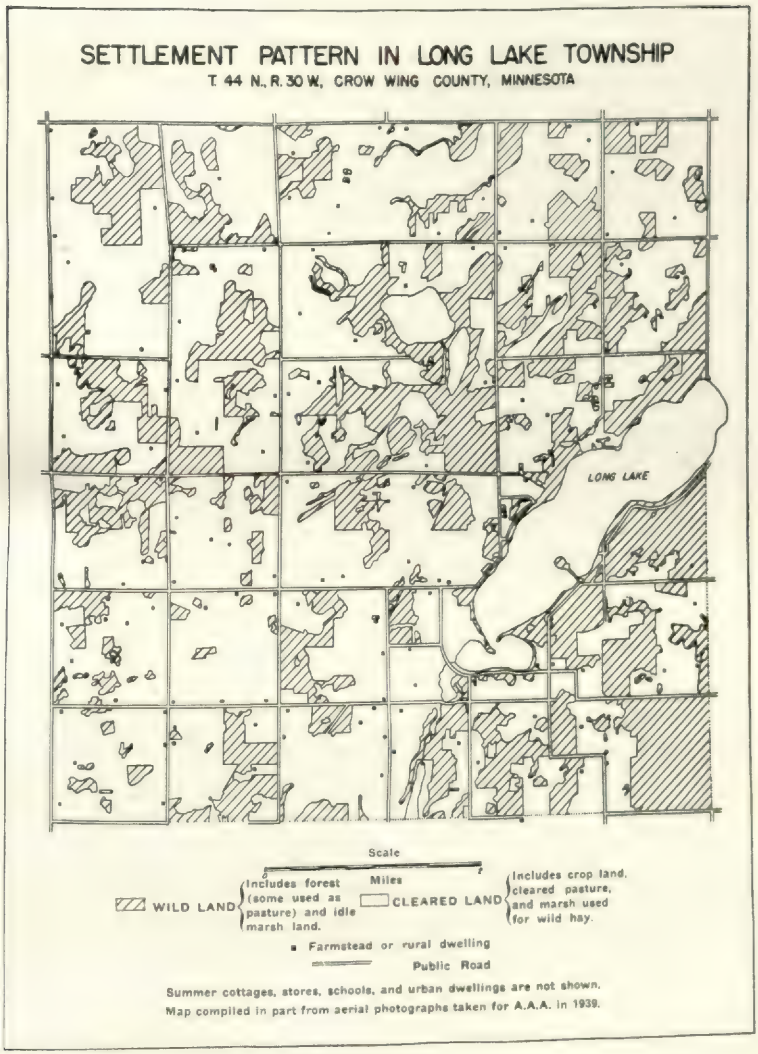

FIGURE 8

Settlement pattern in a township representative of the areas of fairly dense, dispersed agricultural population. Note the rather large amount of wild land still remaining. The landscape resembles that in Fig. 7.

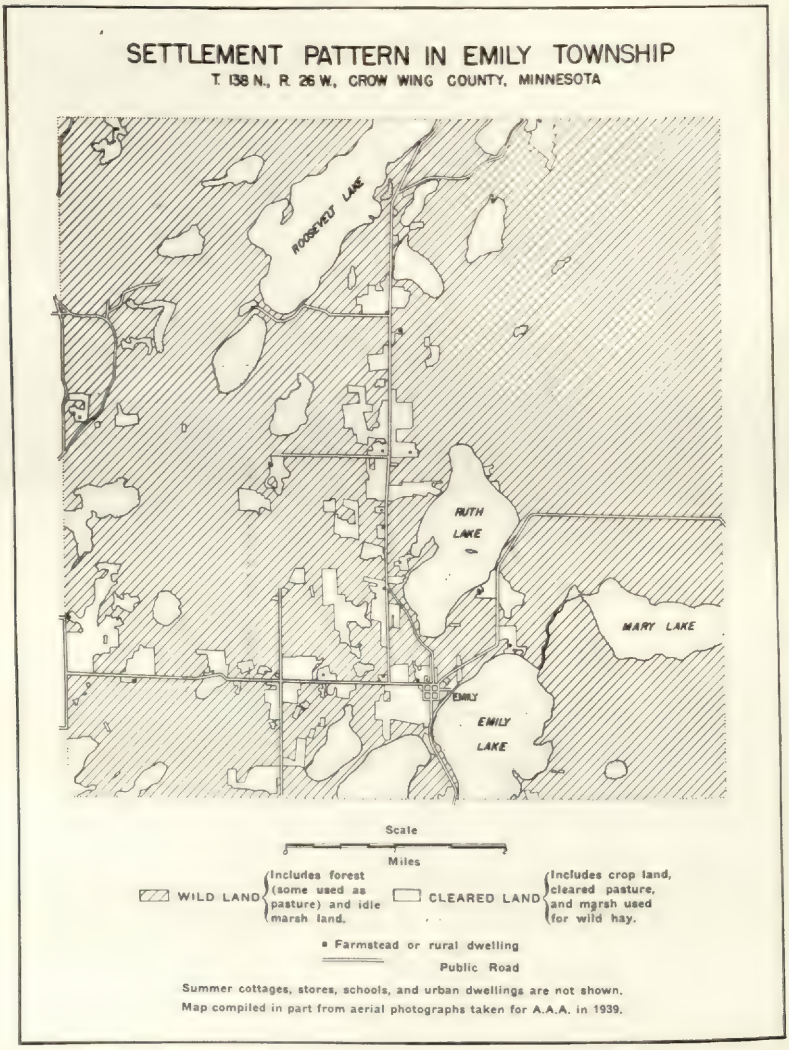

FIGURE 9

Settlement pattern in a township of primitive farms which have created only a narrow fringe of cleared land along the roads. Compare with Fig. 8.

cleared land to make a fairly open landscape; forested wild land is still present, but lies in disconnected patches, and does not dominate the scene (Fig. 7). The pattern of rural settlement in one area of this sort is shown on the map of wild land and cleared land in Long Lake Township (Fig. 8).

In sharp contrast are the areas which are almost without farms; this is the case in almost the whole northeast quarter of the community, and in smaller but extensive areas elsewhere (Fig. 2). In these sections the dots representing agricultural land are arranged in curious linear patterns. One might suspect that farms were concentrated along the roads, and a detailed map of Emily Township, typical of areas of this sort, indicates that this is indeed the case (Fig. 9). The farms are of the primitive type; cleared areas are small, forming only a narrow fringe along the roads, and wild land everywhere dominates the landscape.

The division between the areas of fairly dense, dispersed settlement, and sparse, road-oriented settlement is usually quite sharp (Fig. 10), and transitional areas of intermediate density are almost wanting.

In part, differences in the fundament — in landforms, soils, and drainage conditions — seem to account for these differences in density and type of settlement. A comparison of the maps of land in farms (Fig. 2) and glacial geology (Fig. 11) indicates that this is particularly true in the southern and western halves of the community. Areas of fairly dense settlement and maturely-developed farms lie on the gently rolling till plain (ground moraine) and on some of the outwash plains. The ground moraine along the west edge of the community, identified on the map as Keewatin, seems especially favored; this drift, deposited by an ice invasion from the northwest, has a much higher lime content than the Patrician material, laid down by an earlier tongue of ice which moved from the northeast and brought mostly igneous and metamorphic rocks. As a result the soils derived from the

FIGURE 10

Parts of two maturely-developed farms (in sec. 11, T. 136 N., R. 29 W.) with haying in progress. The picture was taken from a forest look-out tower. These farms are on the edge of a well-settled section, but to the southeast the almost unpeopled, forested outwash plain stretches for miles.

Keewatin drift are usually less acid, hence more desirable, than those which have developed on Patrician material.

On the other hand, areas of sparse settlement and primitive farms are correlated with areas of rough, stony, poor-soiled terminal moraine, and in the lake-dotted central portion of the community, with the extremely porous and hence droughty sand plains. Many of the smaller sparsely-settled or unused areas reflect the presence of swamps, for there are many poorly drained areas in both outwash plains and ground moraines.

These correlations do not apply to the northeastern quarter of the community, however. Here settlement is more recent than in the remainder of the community. This section, remote from Brainerd, and the railroads and main wagon roads which early focused on that city, was nearly unpopulated as recently as thirty years ago. Almost without exception its farms are primitive today, and its road-oriented settlement pattern shows, as yet, little adjustment to the varying adaptability of the land for agriculture.

Viewed broadly, the present state of agricultural settlement in the Brainerd Community, as sketched in the preceding pages, may be summarized in a paragraph. In the portions of the community which lie nearest the southern and western boundaries of the coniferous forest, there has developed, on the best lands, a fairly dense, dispersed agricultural population. The type of farming which supports this population is similar to that found immediately beyond the borders of the cut-over lands, although within the community, yields are lower, and returns less. On the poorer lands within this belt, and in the portions of the community most remote from the borders of the coniferous forest (and from transportation routes) there is a scant population, living on small, primitive farms, pioneer settlers on the agricultural frontier.

As has already been indicated, much of the experimental settlement in the pioneer areas has been a failure; this is attested

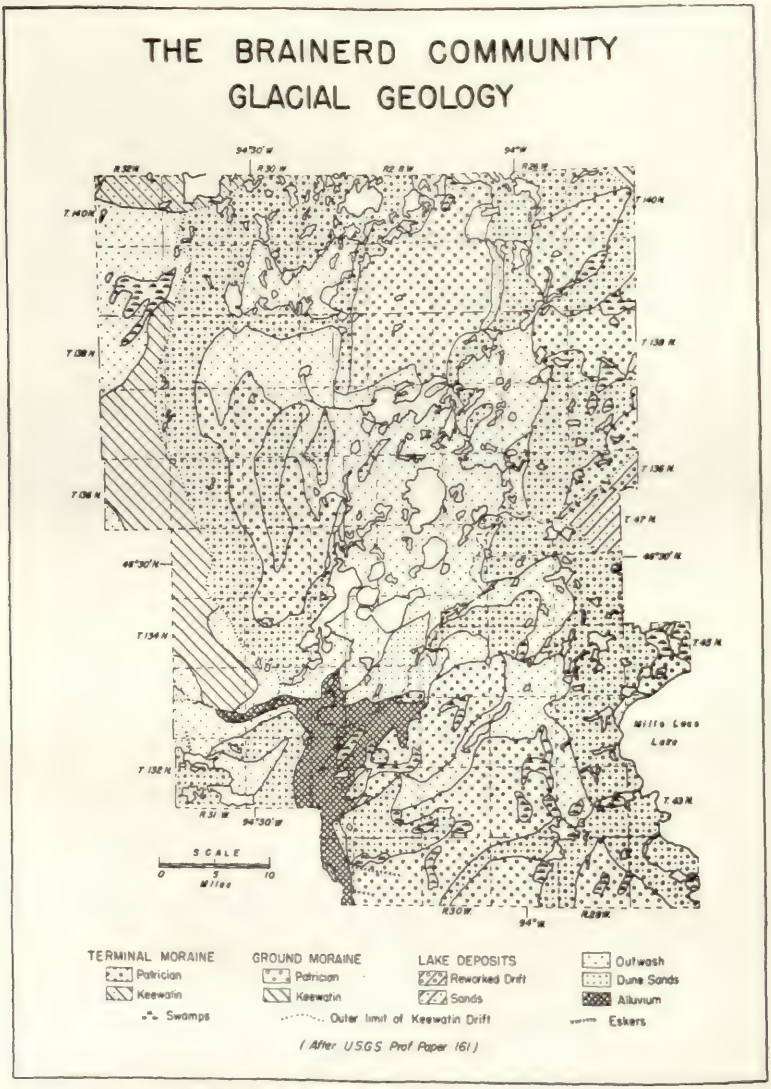

FIGURE 11

Map showing glacial deposits, from which the general characteristics of both soils and landforms may be deduced. Compare with Fig. 2 to see how the settlement pattern, in most of the community, represents an adjustment to these conditions.

by the many abandoned farms, and by the extremely low standard of living in these areas. Frontiers, it is true, have always seen failure as well as success, but today the fate of the pioneer settler is of concern to others beside himself. The modern pioneer, in this area lying close to well-peopled districts and busy towns, demands and gets, as is his right, a variety of public services — notably roads and schools — which must be supported almost wholly by taxes raised in the better-settled sections of his county and state. Unsuccessful settlers receive loans, assistance, or outright relief from local government and state and Federal agencies. Thus the pioneer settlers make their experiments, partly at least, at public expense, and for this reason their use of the land is a public problem. Increasingly, of recent years, there has been a feeling that it may be in the public interest to stabilize the agricultural frontier in northern Minnesota and Wisconsin, and prevent settlement from reaching out into areas where, although the settler may manage to exist, with the help of indirect subsidies, he cannot hope to maintain a decent standard of living. If regulation of this sort is attempted, it will involve some sort of rural zoning program over a belt of considerable width, for as has been seen in the Brainerd Community, areas of present-day pioneering (most of which are of marginal value for settlement) and well-settled areas are closely intermixed.

Issues of the Transactions of the Academy of Science of St. Louis may be obtained by purchase from the librarian, Dr. H. A. Bulger, Washington University School of Medicine.

Volumes I to V consisted of four numbers each, containing numerous articles by Shumard, Wizlizenus, Swallow, Prout, Engelmann, Riley and others. Many of these are still available at $2.00 per number or $4.00 per double number. Beginning with Volume VI each number was issued separately and usually contained only a single article. The following list includes selected issues. Most other issues also are available.

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REPORT ON MOSQUITOES COLLECTED IN ST. LOUIS COUNTY DURING 1942

M. F. DAY

Department of Zoology
Washington University

St. Louis, Missouri

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REPORT ON MOSQUITOES COLLECTED IN ST. LOUIS COUNTY DURING 1942

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Introduction

During the summer of 1942, a survey of the mosquitoes of St. Louis was carried on under the direction of the St. Louis County Health Department. The objects of the survey were to determine what mosquitoes were present in the County and where they were breeding with a view to developing the most efficient means of control of pest, and especially of disease-bearing species.

At the outset of the survey the lack of any quantitative data on the relative numbers of various species of mosquitoes which had been recorded from the area rendered it difficult to recommend control measures, and impossible to judge the efficiency of any program which was instituted. This report is an attempt to fill this need and should serve as a basis of comparison for future work. That others have noted the paucity of data from Missouri is shown, for example, by the remark of King and Bradley (1941, p. 72) who state in regard to distribution of *Anopheles* that "an unexpectedly small number of records is to be found . . . for such states as . . . Missouri, Iowa, Kansas and Oklahoma."

The mosquitoes of Missouri have received mention from time to time in general works. Adams (1934) published an annotated list of 19 species which he had examined, and a more comprehensive list including 41 species was given by Gordon (1940). References to the distribution of Anophelines were given by King and Bradley (1941).

Organization of the Survey

An attempt was made in the survey to utilize the volunteer assistance of Boy Scouts and the Health and Welfare Division of the Office of Civilian Defense. In addition, the following

records include collections made in Jefferson Barracks and by workers appointed by the U. S. Public Health Service "Malaria in War Areas" project who worked in an area approximately one mile from the limits of the Barracks. Without the assistance of these and many others the work would have been less complete. It is a pleasure to thank especially Dr. E. G. McGavran, St. Louis County Health Commissioner, for advice, and Mr. Kenneth J. Wulfert, Assistant Public Health Engineer of the County Health Department for a considerable part in the work. For identification of larval and adult mosquitoes of Missouri the most useful keys and descriptions are those of Carpenter (1941), though King, Bradley and McNeel (1942), Matheson (1929), and Tulloch (1939) have also been found useful. Doubtful identifications have been checked by Dr. J. A. Rowe and Mr. J. Fluno of the U. S. Public Health Service, whose kindnesses are gratefully acknowledged.

Results

1) Species Collected. A total of 981 collections have been examined. Of these 339 or 34.5 per cent were of larvae. In some cases larvae were bred through and the identifications checked with the adults. These collections comprised 15,100 specimens distributed among 30 species and eight genera. The relative numerical importance of the species recorded is presented in Table 1. Of the species listed by Carpenter (1941) as common in Arkansas the following were not recorded during the present survey: *Aedes atropalpus, Aedes canadensis, Aedes thibaulti, Aedes taeniorhynchus, Orthopodomyia signifera.* However, the following species are new records for St. Louis County: *Aedes dorsalis, Anopheles crucians, Orthopodomyia alba, Psorophora cyanescens, Psorophora discolor, Psorophora howardii* and *Uranotaenia sapphirina.*

From Table 1 it will be seen that *Aedes vexans* and *Culex pipiens* together make up 53.5 per cent of the total specimens examined. Third most abundant is *Anopheles quadrimaculatus* the most important vector of malaria in the United States.

Table 1

Relative Numerical Importance of Mosquitoes of St. Louis County — 1942

Species	Adults	Larvae	Total	Per cent
Culex pipiens L.	1,950	2,643	4,593	30.2
Aedes vexans (Meig.)	2,783	739	3,522	23.3
Anopheles quadrimaculatus Say	1,846	461	2,307	15.3
Anopheles punctipennis (Say)	857	751	1,608	10.6
Culex restuans Theob.	435	840	1,275	8.4
Culex erraticus D. & K.	462	240	702	4.6
Culex salinarius, Coq.	280	93	373	2.5
Culex apicalis, Adams	36	131	167	1.1
Aedes sticticus (Meig.)	126	.....	126	0.8
Uranotaenia sapphirina (O.-S.)	72	5	77	0.5
Aedes triseriatus (Say)	55	13	68	0.5
Culex quinquefasciatus Say	29	28	57	0.5
Psorophora horrida (D. & K.)	53	.....	53	0.4
Psorophora ciliata (F.)	29	8	37	0.2
Aedes nigromaculis (Lud.)	36	.....	36	0.2
Aedes trivittatus (Coq.)	23	2	25	0.2
Psorophora ferox (Humb.)	1	14	15	0.1
Psorophora confinnis (L.-A.)	10	5	15	0.1
Anopheles crucians Wied.	13	.....	13	0.1
Aedes dorsalis (Meig.)	8	.....	8	remaining 11 species 0.2
Culex tarsalis Coq.	7	.....	7	
Orthopodomyia alba Baker	2	3	5	
Anopheles barberi Coq.	4	.....	4	
Theobaldia inornata (Will.)	2	.....	2	
Aedes aegypti (L.)	2	.....	2	
Psorophora cyanescens (Coq.)	1	.....	1	
Aedes dupreei (Coq.)	1	.....	1	
Megarhinus septentrionalis D. & K.	1	.....	1	
Psorophora howardii (Coq.)	1	.....	1	
Psorophora discolor (Coq.)	1	.....	1	
	9,126	5,976	15,102	99.7

Table 2

Seasonal Occurrence of Mosquitoes in St. Louis County — 1942

Species	March	April	May	June	July	Aug.	Sept.	Oct.
				Adults X			Larvae —	
Aedes aegypti							X	
dorsalis						X		
dupreei					X			
nigromaculis				X	X	X	X	
sticticus			X	X	X			
triseriatus			X	X	X	X	X	
trivittatus				X	X	—		
vexans		X	X	X	X	X	X	X
Anopheles barberi					X	X		
crucians					X	X		
punctipennis			X	X	X	X	X	
quadrimaculatus				X	X	X	X	X
Culex apicalis			X	X	X	X	X	X
erraticus				X	X	X	X	X
pipiens		X	X	X	X	X	X	X
quinquefasciatus				X	—	X		X
restuans		X	X	X	—	X	X	X
salinarius			—	X	X	X	X	
tarsalis						X	X	
Megarhinus septentrionalis						X		
Orthopodomyia alba					X	X	X	
Psorophora ciliata				X	X	X		
confinnis				X		X		
cyanescens					X		X	
discolor				X				
ferox				—		X		
horrida			X	X	X	X	X	
howardii					X			
Theobaldia inornata							X	X
Uranotaenia sapphirina				X	X	X	X	X
Totals for month — Larvae			5	10	12	11	8	
Totals for month — Adults		3	8	18	20	22	17	9

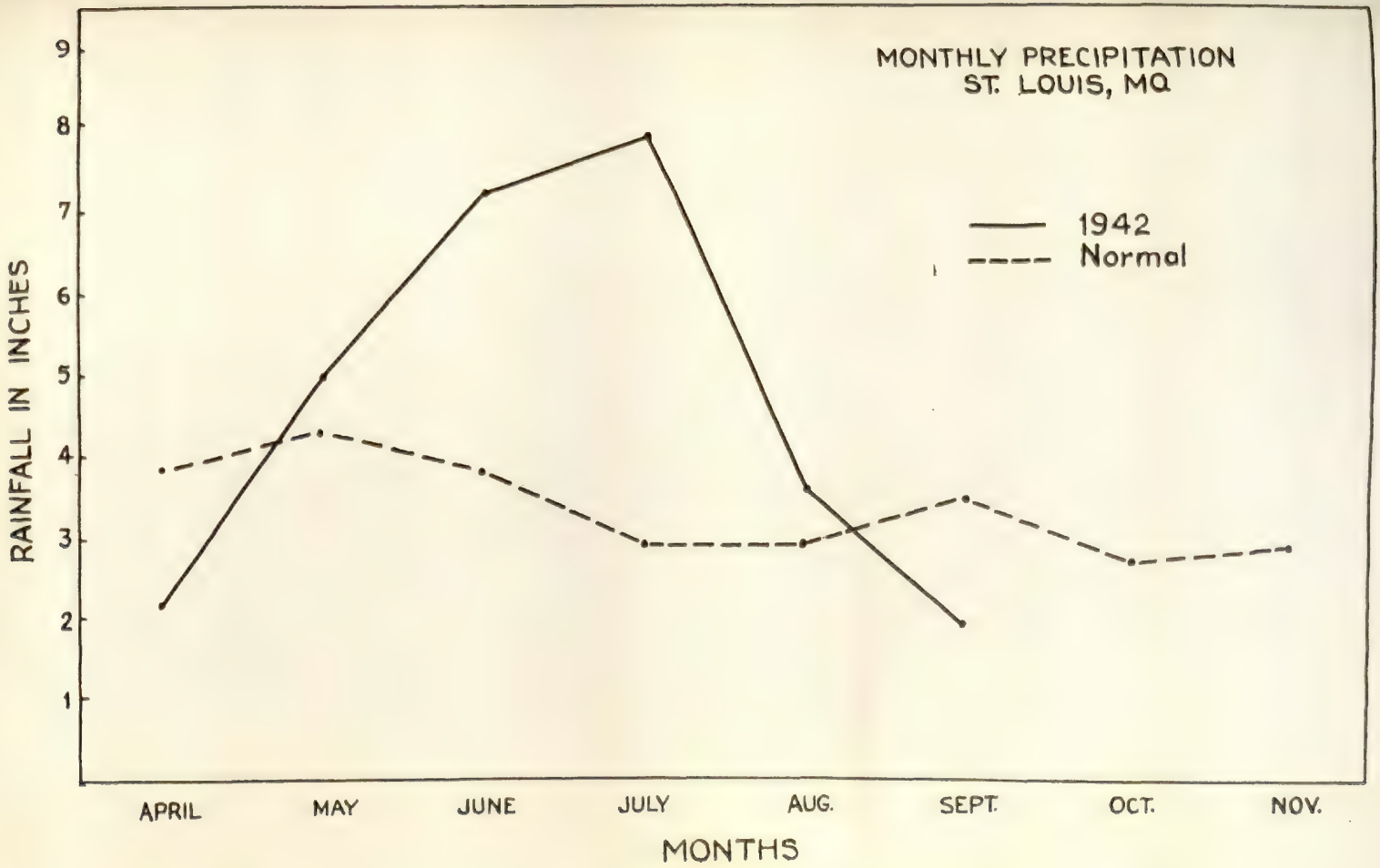
2) Geographical Distribution. St. Louis County, comprising an area of approximately 500 square miles, is situated at the junction of the Missouri and Mississippi rivers and is bordered on the south in part by the Meramec River. There are therefore many natural breeding places for mosquitoes and, while some species are local in distribution, all the more abundant species have been found wherever widespread collections have been made. Admittedly, however, collections have been much less extensive in the western and less populated parts of the County.

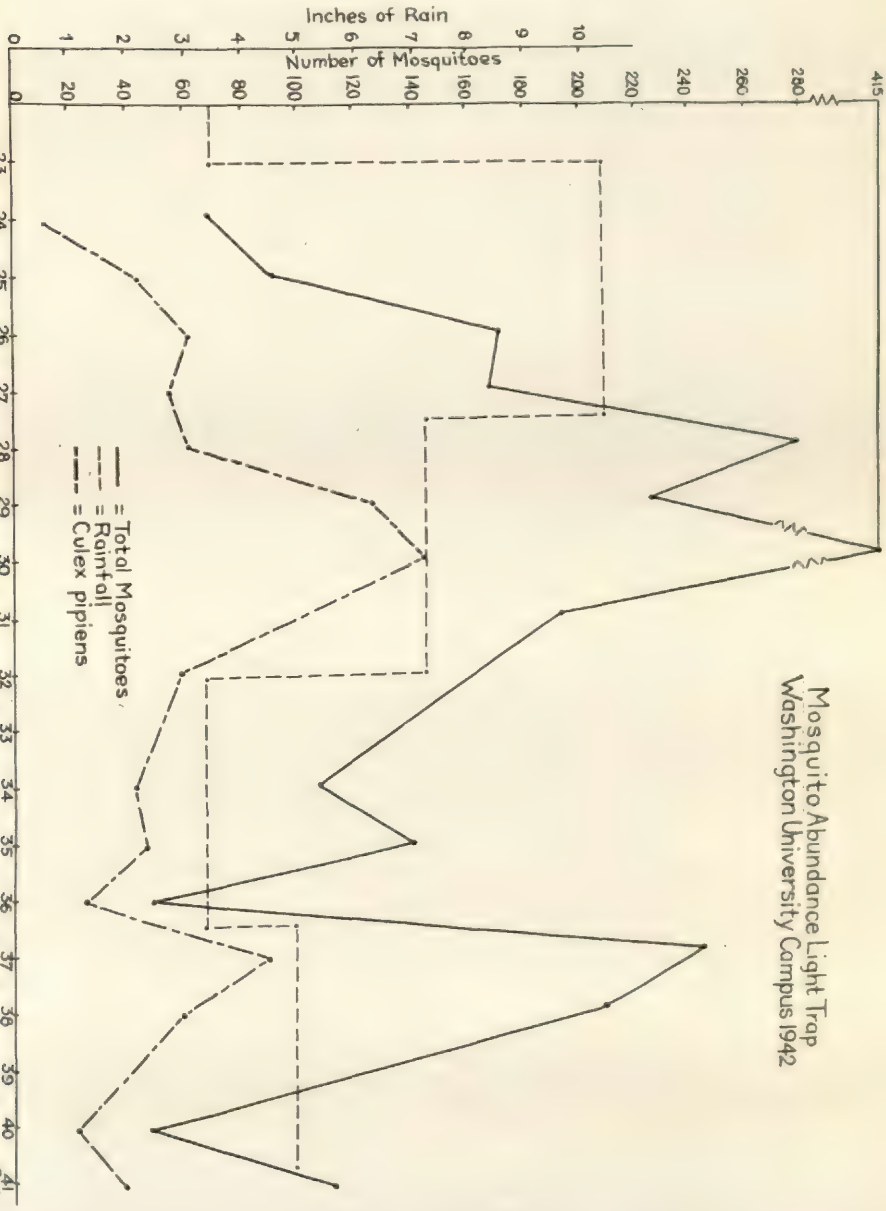
3) Seasonal Distribution and Prevalence. The species found were distributed through the summer as shown in Table 2. Further work will undoubtedly extend these records considerably.

The data from this survey are probably inadequate for a general discussion of seasonal prevalence because of the very unusual weather conditions obtaining during the summer of 1942 as is indicated in Graph 1.

Total collections per month are more an indication of the activity of collectors than of actual abundance, but a more reliable indication of seasonal abundance is provided by the standardized collections from a light trap. Six of these (New Jersey Agriculture Experiment Station Model 50) were eventually set up during the season, but only for one, that on Washington University campus, are the data sufficiently complete for critical analysis. These data are plotted on Graph 2 together with rainfall as registered at the Washington University weather station.

It has been found that, of the total mosquitoes caught in light traps, 43.4 per cent belonged to the genus *Aedes* (41.4 per cent, *Aedes vexans)*; 38.7 per cent to the *Culex*, and 15.3 per cent to *Anopheles*. The number of trap nights on which 24 or more females were taken was 14 per cent. As in the report of Rowe (1942) for Iowa, periods of increased mosquito abundance follow within 10 to 20 days after heavy rain. The maximum occurred in all St. Louis County light traps within a week of the middle of July, following the unusually heavy rain of


MONTHLY PRECIPITATION
ST. LOUIS, MO
1942
Normal
RAINFALL IN INCHES
9
8
7
6
5
4
3
2
1
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
MONTHS


Mosquito Abundance Light Trap
Washington University Campus 1942
Inches of Rain
Number of Mosquitoes
= Total Mosquitoes
= Rainfall
= Culex pipiens
Weeks
June 6
July 4
Aug. 1
Sept. 5
Oct. 3

June and July. It is realized that light trap collections may not give an exact indication of the relative numerical abundance of each species caught, for species differ in their attraction to light. However, hand catches are a no more reliable indication of actual abundance, for species differ greatly in their attraction to man. The following table (Table 3) gives the results of hand catches and light trap catches.

Further interesting information was found when the light trap catches were divided into periods during the night. The campus trap ran almost every night during June, July, August and September from 7:00 P. M. until 8:00 A. M. During a considerable part of this time the collecting jar was changed at 11:00 P. M., so that the collection was divided into two periods, the first covering four hours and the second, nine hours (Table 4). From these data it has been shown that per four hour period there was a significantly greater number of mosquitoes caught during the second period of the night than during the early part. It has also been shown that the sex ratio during the early part of the evening does not deviate significantly from equality, but that there is a significantly greater number of females during the second period.

4) Habits of Mosquitoes. In instituting control measures it is essential to have knowledge of the biting and other habits of the various species. Much information of this kind already ex-

Table 4

Light Trap Records — Mosquitoes of St. Louis County — 1942

	7 P.M. — 11 P.M.			11 P.M. — 8 A.M.			Catch
	Males	Females	Totals	Males	Females	Totals	Total
June	17	19	36	49	125	174	210
July	72	75	147	202	544	746	893
Total	89	94	183	251	669	920	1103

Table 3

Comparison Between Light Trap Catches and Biting Records
St. Louis County — 1942

Species	Light Trap Collections Total 351				Biting Collections			
	No. of Collections		No. of Individuals		No. of Collections		No. of Individuals	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Aedes								
dorsalis	2	0.2	2	0.0	4	4.9	8	1.5
nigromaculis	35	3.0	42	0.7	3	3.7	5	1.0
sticticus	26	2.2	55	0.9	10	12.2	117	23.2
triseriatus	12	1.0	23	0.4	8	9.8	24	4.7
trivittatus	1	0.1	1	0.0	3	3.7	21	4.2
vexans	262	22.3	2506	41.4	24	29.2	256	50.7
Anopheles								
barberi	1	0.1	1	0.0	—	—	—	—
crucians	7	0.6	7	0.1	—	—	—	—
punctipennis	95	8.1	202	3.3	2	2.4	2	0.4
quadrimaculatus	153	13.1	717	11.9	5	6.1	8	1.6
Culex								
apicalis	11	0.9	14	0.2	—	—	—	—
erraticus	77	6.6	263	4.4	2	2.4	2	0.4
pipiens	220	18.9	1439	23.8	4	4.9	11	2.2
quinquefasciatus	9	0.7	16	0.2	—	—	—	—
restuans	107	9.0	411	6.8	—	—	—	—
salinarius	71	6.1	193	3.2	—	—	—	—
tarsalis	6	0.5	6	0.1	—	—	—	—
Orthopodomyia alba	2	0.2	2	0.0	—	—	—	—
Psorophora ciliata	7	0.6	9	0.1	3	3.7	3	0.6
confinnis	26	2.2	46	0.2	1	1.2	1	0.2
discolor	1	0.1	2	0.0	1	1.2	1	0.2
horrida	1	0.1	1	0.0	12	14.6	46	9.1
Theobaldia inornata	2	0.2	2	0.0	—	—	—	—
Uranotaenia sapphirina	38	3.2	88	1.5	—	—	—	—
Total	1172	100.0	6048	99.8	82	100.0	505	100.0

ists for North American species, and the following data in the main confirm previously determined facts; but they are of importance in indicating the situation as it was found in St. Louis County. Table 5 shows the number of specimens of the various species which entered houses and barns, information of considerable epidemiological importance.

While *Culex apicalis* has never been found biting man, the knowledge that its larvae are frequently associated with those of *Anopheles quadrimaculatus* shows that if adequate control of this primary malaria carrier is obtained the breeding places of *C. apicalis* will probably be largely controlled also. Larvae associations are shown in Table 6.

When considered in relation to the type of breeding place preferred by each species (Table 7) it is readily understood why *Aedes vexans* and *Culex pipiens* would become extremely abundant under such weather conditions as prevailed during 1933, the year of the greatest outbreak of St. Louis encephalitis. All reports of that epidemic (see e. g. Public Health Bulletin No. 214, 1935) stress the abundance of mosquitoes, and recent work, especially that of Reeves, Hammon and Izumi (1942), indicates that mosquitoes may be important as vectors of the disease.

From the table it will be seen that the most usual places in which mosquitoes were found breeding were ponds. *Anopheles quadrimaculatus* were largely confined to such areas. Though some breeding places do not fall naturally into the categories listed above, a number of conclusions are justified from the data at hand. The most striking fact is that, while members of the genus *Aedes* make up 32.9 per cent of adult collections, they comprise only 12.6 per cent of larval collections. The situation would be even more marked were it not for the omnipresent *A. vexans*. A comparable situation was found in the 1938 Massachusetts mosquito survey where *Aedes* formed 34.6 per cent of the adults but only 3.9 per cent of the larvae. The reason is prob-

Table 5

Mosquitoes Caught in Houses and Barns — St. Louis County, 1942

Species	In Houses Individuals	In Houses Per cent	In Barns Individuals	In Barns Per cent
Anopheles quadrimaculatus	90	20.8	223	79.4
Culex pipiens	198	45.9	29	10.0
Aedes vexans	68	15.7	6	2.1
Culex restuans	28	6.5	6	2.1
Anopheles punctipennis	8	1.8	9	8.1
Culex salinarius	16	3.7	—	—
Culex erraticus	8	1.8	6	2.1
Aedes triseriatus	3	0.7	—	—
Psorophora ciliata	3	0.7	—	—
Orthopodomyia alba	2	0.5	—	—
Anopheles barberi	1	0.2	1	0.3
Culex apicalis	1	0.2	1	0.3
Aedes sticticus	1	0.2	—	—
Psorophora horrida	1	0.2	—	—
Psorophora cyanescens	1	0.2	—	—
Culex quinquefasciatus	1	0.2	—	—
Megarhinus septentrionalis	1	0.2	—	—
Psorophora ferox	—	—	1	0.3
Uranotaenia sapphirina	1	0.2	—	—
Culex tarsalis	1	0.2	—	—
Aedes aegypti	—	—	1	0.3
Total	433	99.9	288	100.0

Table 6

LARVAL ASSOCIATION

Numbers indicate the times each species was found together.

	A. trivittatus	A. vexans	A. punctipennis	A. quadrimaculatus	C. apicalis	C. erraticus	C. pipiens	C. quinquefasciatus	C. restuans	C. salinarius	O. alba	P. ciliata	P. confinnis	P. ferox	U. sapphirina	
A. trivittatus																
A. vexans	1															
A. punctipennis		7														
A. quadrimaculatus			22													
C. apicalis			23	11												
C. erraticus			16	41	3											
C. pipiens		8	29	7	6											
C. quinquefasciatus																
C. restuans		7	10	2	4	2	29									
C. salinarius			11	3	5		13	1	10							
O. alba				1			1		1							
P. ciliata			2				1									
P. confinnis			1	1						1						
P. ferox		4	2		1		1				1					
U. sapphirina			1	4	1	1										
Number of species associated	1	5	11	8	8	5	9	1	8	7	4	2	3	5	4	
Number of times associated	1	32	124	92	54	63	95	1	65	44	4	3	3	9	7	597
Per cent	0.2	5.4	20.7	15.4	9.0	10.5	15.9	0.2	10.9	7.4	0.7	0.5	0.5	1.5	1.2	100.0

ably to be found in the fact that *Aedes* prefer small, temporary and inconspicuous collections of water, and occur in tree holes.

The figures may give a slightly erroneous impression of the abundance of *Anopheles quadrimaculatus,* because, at least in the Jefferson Barracks area, malaria carrying mosquitoes were particularly studied.

Anopheles punctipennis is found in probably a greater variety of breeding places than any other species. In addition (see Table 6) it has been found in association with 11 other species, more than any other. *A. quadrimaculatus* on the other hand is more restricted in its breeding habits than any species which has been found so frequently. Nearly 80 per cent of *A. quadrimaculatus* larvae are found in ponds. After ponds, ditches and streams produce more mosquitoes than any other of the 16 listed breeding places. Actually as far as numbers of mosquitoes are concerned catch basins must be of great importance, for larvae of *C. pipiens* and *C. restuans* may be found there in enormous numbers.

In rural parts of the county open sewage ditches probably produce more actual nuisances by the mosquitoes they breed than any other source. We have found such collections of water to be literally black with larvae. If the suggestion of Casey and Broun (1938) that there is a correlation between small streams and open sewers and cases of St. Louis encephalitis in the 1933 epidemic, and if *C. pipiens* is shown to be a vector in nature as well as in the laboratory, then such places become a real health hazard in addition to being a public nuisance. The only method of dealing with such a breeding place is the installation of a proper method for sewage disposal. In fact, it will be seen that the vast majority of the mosquito breeding places in the county are man made, or maintained by man. The remainder, such as swamps, streams and lakes could be drained, or treated without undue difficulty.

Table 7

Breeding Places of Mosquitoes of St. Louis County, 1942

Number indicates time species was found in each type of breeding place

Type of Breeding Places	SPECIES																Total specimens in each breeding place	Number of species in each breeding place
	A. triseriatus	A. trivittatus	A. vexans	C. apicalis	C. erraticus	C. pipiens	C. quinquefasciatus	C. restuans	C. salinarius	A. punctipennis	A. quadrimaculatus	O. alba	P. ciliata	P. confinnis	P. ferox	U. sapphirina		
Lakes			1	1		1		1									4	4
Ponds			12	22	37	11		8	4	38	78		2		2	6	220	11
Temporary pools		1	2	1		6		3		9				1	1		24	8
Artificial pools						2		2	1	2	1						8	5
Large artificial containers						3		2			1	1					7	4
Rain barrels				1		3		3	1	2							10	5
Flower containers						2		1									3	2
Tin cans	2			1		1		1		1							6	5
Swamps			1	4	3	7		3	4	8	8						38	8
Streams				5	3	13		5	3	38	7						74	7
Sinkholes						1				2	1						4	3
Ditches			7	2	1	29		13	6	15	1				1		75	9
Open sewers						6		2		1							9	3
Catch basins and inlets			1			16		15		2	1						35	5
Cisterns						2	1										3	2
Excavations			2			4		1		2		1	1				11	6
Number of breeding places for species	1	1	7	8	4	16	1	14	6	12	8	2	2	1	3	1		
Number of times species was recorded	2	1	26	37	44	107	1	60	19	120	98	2	3	1	4	6	531	

Relation to Disease

Anopheles comprise 26.0 per cent of the total mosquitoes. The situation is somewhat comparable to that recorded by Feemster and Getting (1941) for Massachusetts where this genus made up 11.9 per cent of a total of over a quarter of a million specimens identified in the 1939 mosquito survey of that state. Yet there were only eleven cases of malaria probably contracted in Massachusetts in the ten year period 1930-1939 (Getting et al., 1940). In St. Louis County the disease is more prevalent than this, though exact figures are difficult to obtain. Malaria is endemic in the southeast corner of Missouri and many of the cases recorded in St. Louis are doubtless contracted during visits away from the city and county. Since about sixty breeding places of *Anopheles quadrimaculatus* were found and adults were collected in abundance over the whole county the scarcity of the vector hardly seems the cause of the comparative scarcity of the disease. *Anopheles quadrimaculatus* probably occurs in sufficient numbers to account for the small amount of malaria contracted in the county. The actual abundance necessary for the continued occurrence of the disease will vary with a number of factors but the statement of Johnson (1941) that "*A. quadrimaculatus* reduction to the point where only occasional adults are found in suitable diurnal shelter, is effective" in reducing malaria, is significant in this case. The greatest number of this species taken in one day's collecting in barns, culverts and such favorable locations was 410 (August 4). Though *A. punctipennis* is as abundant and bites with great frequency and will transmit the various species of *Plasmodium* in the laboratory, it is not considered important as a vector in nature (Darling, 1926).

In regard to the bearing of the present findings on the possible vector of St. Louis encephalitis, if the disease is mosquito-borne, it seems likely that the vector is probably *Culex pipiens* or possibly other species of this genus. The experimental work indicates a species of *Culex* rather than *Aedes*, but equine encephomyelitis is most probably transmitted principally by *Aedes* (Feemster and Getting, 1941). Of the six species of this genus

incriminated as vectors of the eastern strain of the equine disease in Massachusetts, two have been found in St. Louis County. These are *A. vexans* and *A. triseriatus*. As shown above, *A. vexans* is one of the most abundant mosquitoes in St. Louis County, but *A. triseriatus* is less common in populated areas. The western strain of equine encephalomyelitis has been transmitted by four species of *Aedes* found in St. Louis County (see Davis, 1940).

A special search was made for *Aedes aegypti*, the yellow fever mosquito, which was recently recorded from Jefferson City, Missouri (Adams, 1942), but the species is not common in St. Louis County. A single female was taken on September 17th in the southeastern part of the county, and subsequently several more specimens of both sexes.

Summary

A total of 15,100 mosquitoes from 981 collections made in St. Louis County in 1942 were examined. Of these specimens 34.5 per cent were larvae. Thirty species, belonging to eight genera, were recorded, seven of them being new records for the county. *Culex pipiens*, possibly a vector of St. Louis encephalitis, is the most abundant mosquito in the county and made up 30.2 per cent of the collections. *Aedes vexans*, a vector of equine encephalomyelitis, accounted for 23.3 per cent, and *Anopheles quadrimaculatus* for 15.3 per cent. The latter species is probably sufficiently abundant to account for the malaria contracted in this area.

The unusual weather conditions prevailing during the summer of 1942 suggest that the picture of the mosquito population obtained during this survey may not be typical, but it will be the work of future surveys to substantiate this suggestion.

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of Saint Louis

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SCIENCE IN CONSERVATION DURING WAR TIMES

By I. T. Bode, *Director*
Missouri Conservation Commission

Science in Conservation during war time varies little from Science in Conservation at any other time, unless it be that during war time emphasis on the necessity for adhering to fact and scientific fundamentals is all the more important.

The viewpoints presented here are the writer's own viewpoints. He is fully aware that both the scientist and other administrators may differ with him radically. He believes that closer correlation between scientific and administrative work can come only through a frank recognition of the problems and even shortcomings of both. He presents these comments without prejudice and for whatever they may be worth toward strengthening the conservation program of the State and toward accomplishing enduring abundance of wildlife resources.

The problem of determining proper integration of scientific endeavor is probably as new in the wildlife conservation field as in any field. Much research has been conducted and volumes of scientific facts have been accumulated relating to wildlife. There exist, however, important problems concerning the utilization of all this material. First, there is so much of it that has been left in such abstract form that administrative units are not able to apply it; they are not capable of accurately interpreting it for practical use. Second, until recently, there has been definite resistance between the scientist and the administrator. There is no reason why these situations should continue. It is only fair to state that during recent years the problem of application of scientific findings and that of resistance are disappearing rapidly. A frank facing of the situation on the part of scientist and administrator alike will speed intelligent integration of the two endeavors.

There is involved a two-way consideration. The first relates to the attitudes, problems, and requirements from the administrative standpoint. The second involves attitudes, standards of and qualifications for scientific work, and the evaluation of application of scientific work on the part of the scientist. Following are some of the elements entering the picture.

From the Standpoint of the Administrator

Until recently appointment and background, training and experience of the average administrator have rested largely on

the fact that he was a good political worker, or that he had fished or hunted all of his life. There was a minimum of consideration of his ability to appreciate, analyze, and view wildlife management on the basis of fundamental values and requirements.

Until the present generation there has been an abundance of natural resources. This has generated in the public mind an indifference toward any necessity for management, control of use or looking ahead to determine future and sustained production.

A third element from the administrative standpoint is the fact that, in accordance with human nature, conclusions are reached and management practices established on the basis of untrained observation and deduction. The most common answer arrived at has been that, if the supply of wildlife is going down, the remedy lies in putting more of it into the field. This in turn has given rise to the conception of the game farm and the fish hatchery as the solution to restoration and greater abundance.

Another element in the problem of integrating scientific effort with administration in the wildlife field lies in the source of support for wildlife conservation departments. Nearly all fish and game wildlife conservation departments derive their support almost entirely from the sale of hunting, fishing and other wildlife use permits. Very few are supported to any degree from general taxation. This has naturally resulted in a great deal of intolerance on the part of the man who buys the hunting and fishing permit toward long-time, fact-finding effort. This, together with the fact that so much research and scientific effort up to the present has resulted in abstract data and has stopped short of the final mark, has generated lack of appreciation, doubt, and, in many cases, even ridicule of expenditures for any such effort. It has, therefore, been difficult for an administrator to justify expenditures of money for scientific and research work.

Again, the problem confronting the administrator is often acute and immediately imperative. The time element is important. It frequently is not possible, for example, to await the development and conclusion of a complete life history study of a species to determine whether or not the administration is justified in expending large sums of money each year in trying to establish or maintain that species. An example of this in our own State is the chukar partridge. A considerable sum of money was being spent each year in putting into the field additional stocks of this bird. The Commission was faced with a determination of the justification for continuing this expenditure on the basis of survival and results. The Commission and the admin-

istrative staff needed assistance in approaching an answer to this problem. Research workers were called upon. Had these workers taken the viewpoint that an answer as to whether or not artificial restocking was successful could be obtained only after a complete, long-time life-history study of the birds had been made, we still would be expending several thousands of dollars each year to no avail. The research staff, through whom the Commission approached this problem, realized that they could produce for the Commission an answer to this particular phase of wildlife management, even though it left unanswered many questions with regard to chukar partridge. The result was that, after outlining the proper approach, which only the scientist could do, it did not take long to conclude that the chukar partridge could not maintain itself in our environment and that there was slight justification for the expenditure of the funds necessary to keep the species in existence in this State.

Many of the problems the administrator faces are of this nature, and it is the writer's firm belief that there need be no relaxation in standards of scientific work in order to lift out of the mass of possibilities and ramifications for investigative endeavor these specialized problems for more immediate solution.

As still another element from the administrative standpoint there is the fact that the administrator faces a problem of educating public steeped in long-accepted ideas and of bringing that public to accept new ideas and new truths that result from research work. The administrator, therefore, has a job not only of determining the answer, but of selling that answer to the public which has to use it. The administrator cannot make this sort of a sale unless he can display the product; he cannot display the product of research unless the research worker himself delivers that product in such form that its merits can be understood and appreciated by the uninitiated. I realize that to many highly trained scientists this may sound unprofessional or even vulgar, but nevertheless, it is a fact that must be faced if the scientist wishes so-called practical activity and practical administrative programs to be based on scientific fundamentals.

These conditions have arisen naturally because of lack of training in fundamentals on the part of the public and the administrator; the lack of ability to analyze and evaluate scientific investigation and observation. The problem has been to employ administrators who have this sort of background, and to get results of scientific work translated into usable action programs.

From the Standpoint of the Scientist

It is possible that some of the problems just mentioned might not be so acute if our conception and measurement of standards of good scientific work had been interpreted in a dicerent way; and it is possible that the scientist has been as intolerant of the person who did have the scientific viewpoint as that person has been of the scientist.

There has been some tendency during recent years to discuss rather glibly various types of scientific work; as for example, "pure research;" "investigation;" and "applied research." The writer is not sufficiently scientific-minded himself to even suggest that any such division is or is not possible or justifiable. He only knows that this situation exists, that this has given rise to a tendency among scientific workers to distinguish between and evaluate the work of certain groups of investigators on the basis of such a classification, and that there has arisen evidence of depreciation of the professional standing of the so-called "applied" scientist and an attempt to place a premium upon the so-called "pure" scientist. Among certain workers there is a fixed belief that no work is scientific or to be evaluated as bona fide research unless the worker himself is left to wander at will, to follow any leads or ramifications that may suggest themselves, to follow through for the sole purpose of producing information, whatever it may be, and regardless of whether it can ever have practical application or not. There are some workers who, it sometimes appears, even believe that the less application scientific material can have, the more "pure" it is. An administrator feels sometimes that the end product is developed with the idea that the more it can confuse and the farther it can remain above the comprehension of the uninitiated the higher is the standard of the work. This is somewhat of an exaggeration, of course, but it illustrates the point. Many scientists have had a tendency to look askance at investigators of pure administrative problems.

On the other hand, there has, no doubt, been much justification for the reserved attitude on the part of the scientist, because, all too frequently, from the administrative standpoint, there has been too much of a tendency to require an investigator to prove a point which is vital to the administrative field, but which proof may not be altogether honest. If that investigator has not been able to conscientiously produce data and information which will substantiate a pre-conceived viewpoint, he is out of countenance with the administration. This should not be so; and, again, it

is gratifying to note that within recent years this attitude is rapidly breaking down.

Neither is it intended to imply through these comments that all scientific endeavor should have as its objective only practical application. The very foundations would be torn from under science and progress if workers in this field, who choose to do so, were not free to investigate and follow through at will wherever their interests lead them and upon whatever ramifications present themselves. It is an insult to Science itself when the "practical" or administrative field requires any investigator to set forth data, presumably factual, when those data are anything else but the truth. There may be times when the use and presentation of such data would be so far in advance of the public mind that their application must be postponed until such time as the public is ready to accept them, but there should be no justification for an administration to propound an untruth in the guise of scientific fact. Science is entirely justified in holding to such standards.

Scientific Endeavor Finding Its Place in the Administrative Field

The writer remembers the time when there were practically no technical or research men on any of the administrative staffs. Then came a time when here and there a few began to filter in. They were viewed with reserve on the part of administrators, and were viewed somewhat as outcasts by scientific groups. Then followed the time when a few with research training, or at least with a full appreciation of scientific and research work, took up administrative positions. At the present time there is ample evidence that a premium is being placed by administrative agencies upon thoroughly technical men, especially if these men have had experience with practical field problems.

It is gratifying to note that, where formerly an administrator had to be diplomatic, adroit, and skillful if he presented to the layman any results dealing with wildlife management that were contrary to popular belief or commonly accepted tenets, he may now do so more and more without impugning his own reputation or that of his entire department. Again, it is gratifying to note that more and more administrators feel free to adhere to fundamentals resulting from scientific investigation regardless of former popular opinion, and that there is a growing realization of the necessity of adhering to such fundamentals, no matter by what group or agency they are developed and established. There

is also a growing appreciation on the part of administrators that there must be a constant search for the truth, and that sooner or later any practice or policy will be a failure unless based upon such truth and such standards as are backed by scientific and research endeavor.

There is a growing realization that the lowering of standards of scientific or research work is not at all necessary in order for such work to be of value to an administrative department. There is also a growing realization that scientific work can best be conducted by agencies and at institutions which are equipped to handle it, and that much duplication can be avoided and a much higher standard of work accomplished where administrative departments do not attempt to establish highly developed research agencies.

In Missouri the Conservation Commission has been following this policy. Since its first year the Commission has been cooperating in a research program with the University of Missouri and the U. S. Fish and Wildlife Service. There are only eleven such units in the country. The work is conducted at the university where personnal, library, laboratory, consultant and other facilities are available. Any problems the Commission faces involving technical phases or requiring research study are referred to this unit. The money expended for this work has been a good investment. Answers are being developed to such questions, as:

> What causes quail populations to fluctuate and how can we determine quail populations from year to year so as to permit as liberal a use as possible of surplus and yet preserve breeding stock?
>
> Is the cry raised in certain quarters that shipment of live rabbits is depleting our rabbit crop justified?
>
> What hope is there for restoring the wild turkey sufficiently to permit hunting?
>
> What are requirements for deer ranges and extension of the range?
>
> Under what form of management can raccoon and other furbearers be restored and their value increased?
>
> We are convinced that wildlife restoration is intimately associated with the land and land use, but how and to what extent? Is it soil and plant food? Is it land use practice only?

These, and a number of other problems, are being given consideration by the research unit. At first glance this might

lead to the conclusion that there are largely administrative, but such is not the case. The farther the work proceeds the more certain it becomes that the answer to any one of the questions involves careful research which an agency such as the Conservation Commission is not prepared to carry on.

The Commission is concerned in research work from another angle. This work is being conducted through what is known as the Federal Aid to Wildlife Program. Funds for this work are made available through the excise tax on arms and ammunition; seventy-five per cent of the funds are made available by the federal government and the state agency contributes twenty-five per cent. This program provides for a limited amount of research work. The nature of the research work conducted under this projcet is somewhat different from the cooperative research work just mentioned. It takes on more of the nature of field investigation. The Federal Aid to Wildlife Program is not limited to investigative or research work, but because of the newness of the wildlife program in Missouri and the need for establishing foundation facts, Missouri has chosen to devote the major part of its allotment of Federal Aid to Wildlife funds to field investigative work which will ultimately lead to the development of our action program. The underlying objective of Missouri's effort during the past five years has been the investigation of the incentives needed to encourage adoption of practices favorable to restoration and increase of wildlife resources. Even in this program there have been many phases of work that have required coordination with the research unit at the University. The result has been that there has been no duplication of effort, but both the cooperative research program and the Federal Aid to Wildlife Program have dove-tailed into a research or investigative project which has fully carried out the principles outlined in this discussion. As a simple example of the results of this type of approach as a foundation to wildlife management, mention can be made of the farm pond program. Research investigation, in cooperation with the Federal Aid to Wildlife Program, had shown that one of the outstanding needs of wildlife restoration in Missouri was an adequate distribution of watering areas. The investigations carried on subsequently by the Federal Aid to Wildlife project pointed the way to cooperation with landowners in establishing these watering areas by means which also furnished the farmer better live stock ponds.

A second objective of the Federal Aid to Wildlife Program was the development of foundation plans for wildlife management for the various species in the State. Founded upon the

work of the research unit during the past five years, the Federal Aid to Wildlife project effort has developed to the point where the management plans for various species of wildlife are nearly completed. This will form a foundation for a constructive program of wildlife restoration for the State.

It is not possible to give a very complete picture of the full implication and scope of the Commission's investigative and research program in the space of this paper, but the foregoing brief outline will give some idea of the importance that the Conservation Commission attaches to fundamental research and to the necessity for developing the application of the information developed by such research.

What is the Picture for the Future, and Especially During War Time?

There is much comfort in the fact that, in spite of the pressure of war emergency most agencies are conducting wildlife conservation affairs on the basis of sound principles of production and management:

1. Sustained harvest, even for war purposes can be maintained only by maintaining breeding stocks.
2. Harvest can be increased only by utilization of surpluses where such exist or by increasing breeding stocks.
3. Not even war demands can be met if in a single year the foundation stocks are eliminated.

Administrative work more and more, and especially in war time, must be based on fundamental research.

The pressure of war emergency will require the fullest, most intense, and most cooperative type of endeavor possible on the part of science, if the wildlife resource is to be preserved.

Both during the war period and in the future, more and more trained research and scientific men will find their way into administrative positions. The scientific field could well encourage young workers who exhibit administrative ability along with their scientific ability, with the idea that scientists can be good administrators and that good administrators can arrive by the way of scientific training.

The administrator needs men who not only are thoroughly familiar with biological principles, but who can analyze a problem, and who can learn to steer a path through a mass of extremely interesting and valuable ramifications and keep his fingers on the key problem. He must be able to go at that problem,

concentrate upon it, and be willing to place in the hands of the administrator all of the assistance he can as soon as he can, even though later on it is entirely possible to work back to some of the causes and reasons and ultimately produce a much more complete piece of work.

The administrator is in need of scientific men who are willing to do a certain amount of service work, and who can translate their technical knowledge and skill into information and practice that the layman can comprehend and use.

These results can be accomplished only if we realize what each other's problems are. They can come only if the scientific field finds the means for developing a full appreciation of administrative problems and finds itself willing to adjust its evaluations and scope of activity in such a way that scientific results can be made use of and the worker associated with the more practical phases will find full acceptance of his status and effort as bona fide scientific accomplishment. They can come only when the administrator appreciates the full significance and need for expecting only scientific truth and complete integrity in presentation of investigative output from his research workers.

Summary

Summing up briefly, the scientific need in the wildlife conservation field is to know not only *what* to do, but *how* to get it done.

An attitude on the part of the scientific worker that it is not his function to go beyond the production of facts may be entirely justified for much scientific work, but this should not work to the exclusion from scientific classification of those efforts which involve the field of application.

The scientific worker who has the ability not only to develop facts, but also to assist the administrator in working out the application of them and their adoption, is head and shoulders above the one who has no ability to go beyond the point where many valuable data are produced but left dangling in the air because the administrator and field staffs do not have a thorough enough grasp of interpretation of facts to pull them down without getting them all twisted up and misconstrued when given application.

The administrator who expects a research worker to distort his data and color his integrity for the sake of expediency is not using science to build sound wildlife management.

Science and scientifically trained workers are more and more finding their place in the wildlife administrative field.

The writer suggests the following slogan for any research worker who really wants to be of assistance in obtaining the goals in wildlife conservation work: "What can we do with what we know?"

The writer would recommend that somewhere in the training of every scientific worker he be required to have several years' experience in the administrative field.

SCIENTIFIC APPROACH TO THE CONSERVATION OF FISHERIES RESOURCES

By Aden C. Bauman, *Aquatic Biologist*
Missouri Conservation Commission

The Conservation Commission is charged by the 1936 constitutional amendment with the responsibility for the conservation of wildlife and forest resources in the State of Missouri. That the fisheries are an important part of the wildlife resources of the State is made evident by the fact that the varied conditions which occur in the 18,000 miles of intermittent and flowing streams in Missouri afford habitats for over 225 species and forms ranging from the smallest to the largest of American freshwater fishes.

In dealing with the conservation of fishes the Commission recognizes two points of view and likewise two possible approaches to the treatment of the subject. The first is the popular concept which follows the conventional lines of conservation, being more or less a regulatory proposition looking mostly to the protection of existing stock and regulation of harvest. In this type of conservation, according to the thoughts of the average persons, water alone is enough for fish production, and in the lives of fishes they reflect their own likes and dislikes, assuming that the habits of fishes conform to human temperaments and vagaries.

In the scientific concept, fishes are recognized as coldblooded animals with basic physiological requirements not unlike those of humans, the service of which, however, differs to a great degree. This concept recognizes the fact that the conservation of fish is based on environmental requirements which may be influenced by factors remote and difficult to recognize. The fish is considered the end product of aquatic influences, both chemical and physical, some phases of which are not known.

In practice, the Conservation Commission necessarily and wisely avoids abandoning too abruptly the practices that conform

to popular notions, some of which may not be wholly sound. While continuing these practices, it is launching fact-finding investigations using methods which are recognized as conforming to the requirements of scientific procedures. The application of such scientific methods is being introduced as rapidly as the "traffic will bear," but it is significant that the practices and procedures adopted are being determined by and based on reliable scientific facts. It is to this end that a brief insight into the analysis of an aquatic environment is now presented.

An aquatic environment is the end result of all conditions and factors existing within the entire watershed which furnishes water to supply a medium in which life exists. Sometimes the watershed is so far removed from the water medium that its source cannot be determined, as in the case of streams fed by springs whose sources may be in far away solution basins. Nevertheless, the habitat is directly dependent on and affected by it, and the chemical composition of aquatic solutions can be only of those chemicals with which the water has contact.

No life can exist for any length of time in pure water. Chemical substances must be supplied to the water if it is to support life. These chemicals, either organic or inorganic, are the foundation for the ladder of aquatic life extending from microscopic plankton through the invertebrates up to the large vertebrate animals. Since the bodies of plants and animals are composed of complex chemical compounds, there must be a chemical reservoir from which the building-materials of these compounds can be obtained. The watershed, including soils, plant and animal debris, and atmospheric suspensions, is the reservoir from which life-building elements are drawn. The water, falling as rain and later running off, serves as the transporting solvent, moving the dissolved or suspended chemical substances into the stream, which in this case is taken as the biotic medium.

Microscopic or semi-microscopic organisms living within this medium take these chemicals directly into their cells by ingestion of colloids or diffusion of solutes for use in their chemical or physical make-up. These small living aquatic forms, generally known as plankton, furnish the chemical foundations on which the higher aquatic life is built. Larger organisms, usually visible, depend on the plankton for substance and in turn are consumed by higher forms of life, such as small fish, insect larvae, worms, shrimps, amphipods and other similar animals. This might be compared to the middle rungs in the ladder of aquatic life, while the upper rungs are represented by the larger aquatic vertebrates

— fishes, amphibians, reptiles, birds and mammals which feed on the smaller forms.

When the importance of interrelation of aquatic forms as forage for other animals is realized, one can look briefly into another relation in the aquatic association. Among the larger forms there is much competition for food, the smaller members of a species serving as food for the larger ones. There is no regulated provision as to what each shall eat, but certain natural laws apply so that there is a survival of the fittest and a retained balance of nature.

Water alone is not enough to produce fish; it is only the medium in which fish exist. It also serves as the vehicle, as considered before, for transporting necessary chemicals, oxygen, and food to the fish, but these are not produced by the water — they are supplied to the water through a chemical linkage with the watershed or atmosphere. Besides these primary relations of water to fish, there are other important habitat necessities for the well-being and growth of fishes.

A fish, like other animals, must have living room; that is, a certain necessary volume of water is required for each fish in which it can have freedom of movement without too close contact with other fishes. Some fish prefer close association with other individuals, but in that case the school requires living room comparable to that required by a larger fish. The volume of water for each fish must have certain dimensions within limits, for depth is important in that some species require much greater depth than others.

It is not the nature of fishes to expose themselves to plain view, though at times garfish and black bass spend certain times floating quietly at the surface. When not feeding or swimming leisurely about, fishes demand a place of retreat in which they can lie unobserved, unmolested and in proximity to physical shelter. This shelter may serve as the individual residence of a fish, to which it can retreat when alarmed or from which it can dart to seize its prey. Sediments in water furnish cover, in a certain sense, by making a fish invisible from without; depth of water, if great enough, also serves as cover, but the most satisfactory cover is logs, brush, boulders or general debris. These not only afford a retreat with which the form and colors of fishes blend, but if dense enough they completely conceal the fish, and provide physical contact and security.

The most important requirement for continuation of a species is a surrounding in which it can reproduce. For the many species of fish this requirement varies so widely that no general description of suitable spawning grounds can be given; however, most of the species will spawn on riffles, in vegetation, in cavities, or on cleaned gravel areas. If a continuation of the species is desired, suitable nest locations must be available and the breeding adults must be protected at the time of nest building, spawning, and nest guarding. Eggs will smother if silt is allowed to settle on them, and this often happens when silt-laden waters cover spawning areas following a sudden downpour in an eroded watershed.

After the eggs have hatched and fry have emerged from the nest they are attractive morsels for slightly larger fishes and other animals. If, then, these fry are to survive, shelter is a "must," and the cover which serves the requirements of adult fishes cannot serve also the fry. Finer-texture cover is needed for small fish — weeds in shallow water providing optimum conditions, for here in shallow water the small fish are in their feeding area, the large fish avoid it, and the plants attract food. Such cover is necessary for young fish until they mature enough to compete with the larger fish in the main stream.

The cardinal necessities for fish production may or may not be present in proper proportions to constitute a suitable habitat for fish. In a state the size of Missouri, with many thousands of miles of water, the only way in which a full set of scientific facts can be accumulated is to study each stream in a standard way and the gathering of scientific data on a stream or body of water by trained personnel using standard methods and unbiased judgment constitutes an aquatic survey. This is necessary if facts relative to all waters are desired, for though each stream is well known to some individual, there is no one familiar with all waters. Furthermore, observations made by several individuals may vary widely and may be biased, with the result that not facts, but opinions suiting the fancy of the individual are obtained.

Actual measurement of pool depth in relation to its length and volume, along with the pool-riffle ratio, gives a fair index of the living room afforded fishes in a stream. Chemical analyses of the waters show the compounds present as well as their concentration. Qualitative and quantitative studies made on the bottom fauna available for fish food, added to the free swimming forage forms such as minnows, crustacea and insect larvae, give

the total of available forage. These forage forms are, of course, dependent on the plankton, ooze, and other microscopic substances. A field examination of spawning facilities involves simply observing whether pools or riffles provide the desired depths and bottom composition, but post-season observations cannot detect a possible loss of 100 per cent of the eggs in a flood during the spawning season.

The survival of the yearly hatch can be roughly learned by methodical collecting of fry or fingerlings in the summer from marginal weed beds in which most of these fish take refuge. After the fry emerge from the nest, the necessary physical cover and shelter must be supplied if these fish are to reach maturity. For larger fishes, debris, rocks, windfalls, and undercut banks supply suitable cover. The degree of sufficiency of cover can be mostly learned by observing its presence or absence and comparing this with a count of netted fishes removed from the available cover. The aforementioned types of cover still do not constitute serviceable cover if it is not in water of great enough depth.

The Missouri Conservation Commission has been conducting such aquatic surveys by watersheds, mostly during the summer months beginning in 1939. These essential facts for fish production ascertained and consolidated into an understandable whole will give the Missouri Conservation Commission an index to stream productivity and a guide by which it can initiate a planned watershed and stream-improvement project to correct any deficiencies which are limiting fish production in the waters of the State.

Survey data and their interpretation indicate that watershed, stream slope, and stream-bank erosion can be designated as the most important factors limiting production in the streams, for this condition in turn has limited several production factors within the streams themselves. The flushing of sediment and gravel into streams fills pools and channels with a result comparable to shrinking the stream-length and restricting the extent of the aquatic medium; fish foods are buried or crushed by moving gravel; spawn is buried or smothered by sediments; aquatic vegetation is destroyed; and cover or shelter for larger fishes is obliterated.

In attacking this problem the Missouri Conservation Commission is looking for the cause in the watershed as well as the effects in the stream, and a coordinated program including improvements of both is under way.

"CONSERVATION OF GAME"

By A. S. Leopold,
Game Technician, Missouri Conservation Commission

Like many another applied science, the field of wildlife management has grown steadily in breadth and complexity. From the direct and obvious approaches to wildlife restoration, such as legal protection, refuges and restocking, we have progressed into the more difficult, but in the long run more basic, enterprise of attempting to correlate the principles and practices of good wildlife conservation with all other land uses, to the end that maximum game yields may be produced on *all* lands, compliant with other interests. Game crops need not be solely the products of "submarginal" or waste lands. Small game, like quail, rabbits, squirrels and some furbearers can be produced on the best dairy farms without interfering with the flow of milk. Deer and wild turkeys may be an important by-product of well managed forests. Wildlife products, such as foods and fur, in addition to the important recreational values, are potential supplementary crops of all the farms and woodlands of Missouri. A wildlife program, based on this thesis, adheres to the principle of multiple use of the land, and in war time or in peace, this is good economics and good conservation.

To adequately provide for the needs of wildlife in a balanced program of land management, it is important that our plans dove-tail with the objectives of the agriculturalist and forester, the erosion control engineer and the economist. As one of the lesser products of the soil, wildlife is due its place in the future pattern of rural economy. This is the field of long-range land planning, a vital concern to all agencies dealing with the land and its products.

But prerequisite to planning an action program, we must have at our disposal a considerable array of factual material dealing with the wildlife itself, its needs and environmental requirements. Thus has arisen a demand for far more information than we have possessed in the past on the numbers and distribution, food habits, cover and water requirements, mobility, productivity and general ecological relationships of all important species of game. The relatively new but increasingly important field of wildlife research attempts to provide this information on which future management programs are based.

The research programs of the Conservation Commission and the Cooperative Wildlife Research Unit in Columbia have already contributed to our knowledge of a number of species.

Studies of bobwhite quail, prairie chicken, wild turkey, deer, raccoon and several other species have been undertaken, and certain segments of these studies have been concluded. None, however, are really completed, for we have just scratched the surface in our understanding of the complex relationships of all these organisms to their environments. As nearly as we can see now, the research program can profitably be extended indefinitely, much as researches in agriculture, forestry and other applied biological sciences.

But even now, certain principles have emerged from the collective results of these studies that are useful in formulating policies of management. It has been found, for example, that all over Missouri, water supplies for most species of wildlife are generally lacking. The construction of permanent ponds, in most cases primarily for livestock water, has been met with immediate response from quail, raccoons, waterfowl and other forms of wildlife. In the Ozark region, ponds have attracted deer and turkeys to many dry ridges, formerly unsuitable for occupation. Thus the Commission has felt justified in sponsoring a demonstration pond program throughout the state, which is very attractive to farmers because of the added supplies of livestock water, but from our standpoint is most important in meeting the needs of a number of game species. This is one example of the overlapping interests of the agriculturalist and the conservasionist.

Similiarly, all studies of woodland game have demonstrated the deleterious effects of forest fires on game production. Not only do fires cause direct losses among the birds and mammals themselves, but they seriously damage the range, destroying food and cover essential to the maintenance of game populations. And also, burning despoils the timber, destroys rangeland forage for livestock, and accelerates the destructive processes of erosion, with resultant ill effects on fish production in rivers and streams. In this case, the interests of the forester and lumberman, the livestock owner and wildlife manager must center on the same objective, the elimination of fires in our woodlands. To insure the protection of game and fish, as well as the forest resources of the state, the Commission has undertaken a program of forest fire control, coordinated with and supplementing the activities of the U. S. Forest Service and others concerned with forest and range management. Again the interests of several land use agencies have proven to be identical. From these and similar examples, the conclusion can be drawn that in general, good soil conservation, and good agriculture and forestry, are also good game conservation.

The above cases illustrate two types of action programs that are carried on by this Commission, which benefit wildlife as a whole. Sometimes it is also desirable to draw specific, state-wide management plans for single game species, or closely related groups of species. To illustrate the various stages in arriving at a management program for one game bird, I will present some of our findings on the wild turkey, which I have personally contributed to, and feel qualified to discuss.

A logical first step in the study of any species is a survey of its current status and population trend. Thus, in the winter of 1941-42 a state-wide census of the wild turkey population was undertaken, to determine the extent of occupied range in Missouri, and the number and distribution of birds. Altogether, 590 flocks of turkeys were located, distributed through 30 counties, nearly all in the Ozark region. The number of birds in these flocks totalled 4,340. A backcheck on one sample area indicated approximately 85 per cent accuracy in the census method, which was reasonably good. In 1935 a similar though less detailed survey had found only 3,585 turkeys in the state. This showed a 20 per cent increase in turkeys during an eight-year period, which certainly was not great, but still encouraged us in the belief that the species could be restored. The figures also substantiated our previous belief that the turkey population was still far too low to warrant an open shooting season, and the information was thereby of immediate use to the Conservation Commission in formulating its regulations.

From this survey we were able to deduce other important points. In comparing the turkey map with the soils map of Missouri, we found a definite correlation between the distribution of turkeys and the occurrence of certain soil types within the Ozark region. The Clarksville Stony Loam, a thin but fairly well limed and fertile soil, supports four-fifths of the turkeys in the state. Practically all turkeys have disappeared from large blocks of timbered land in the eastern Ozarks, underlaid by granite and deficient in calcium and phosphorous. Conditions of protection, cover, water and amounts of food appear to be quite comparable in both types of woods, so the deficiency in the granite soil lies, presumably, in the *quality* of food produced. Thus we learn that the mere presence of a forest is no assurance that an area is good turkey range. The fertility of the soil underlying the forest may itself be a limiting factor. The conclusions reached in this case are being borne out by a more extensive, current survey of sample areas throughout the state; in many other species, distribution and local density seem to be directly correlated with soil

fertility. This resolves itself into a question of nutritional deficiencies among the wild birds and mammals. Although the physiological aspects of the problem are far from explained, the immediate uses of this information are obvious. In planning the future program of turkey management in the state, for example, we shall certainly evaluate all potential range in terms of basic soil fertility, and thereby save useless efforts and expenditures on lands fundamentally unsuited for turkey production. Deer, on the other hand, appear to have a somewhat lower threshold of tolerance in their nutritional requirements, for they do fairly well on the inferior granite soils. The possibility of deer management in the granite country is thus held open.

Detailed studies of local turkey populations have yielded additional information. We find that despite a greatly improved system of game protection and law enforcement, poaching is still an important factor limiting turkey increases in the Ozarks. Relief from poaching, through intensive local patrol, has produced prompt gains in turkey numbers. Protection, which was the earliest recognized factor in wildlife restoration, has not diminished in importance today, and remains a critical factor in the management of many game species.

In comparing the productivity of our several state game refuges, we note that turkeys have done best on refuges suffering the least internal disturbance. Development of too many roads and picnic grounds, excessive work in the timber by CCC crews, and other forms of human disturbance will drive turkeys from an area, thereby defeating in part the objectives of a refuge. The wild turkey has a relatively low tolerance of disturbance, and this must be taken into account in local management plans.

Furthermore, best results in nearly all our turkey management projects have been obtained with truly wild, native stock. Admixtures of domestic and wild stocks have not proven very satisfactory subjects for management in the wild, a factor which must receive consideration in restocking projects. Within the main occupied turkey range it seems best at this time to concentrate on protection and management of the remaining wild stock, reserving further experiments in restocking for Ozark border areas from which the native turkeys are gone.

The importance of fire control and the development of water resources, both of which affect turkeys, have been mentioned. All these bits of information, as well as the findings of the turkey survey, will contribute to the state-wide plan of management for the species. It is our belief that only by constructive, long-range

planning, based on facts such as these, can we bring about the restoration of some of our disappearing forms of wildlife like the wild turkey. I have used the turkey here only as an example of the processes of study and planning that characterize sound wildlife management as we see it today. Similar procedures are being followed in other important species.

The objective of the present game restoration program in Missouri is, of course, the production of ever increasing yields of wildlife crops, for both the recreational and aesthetic values, and the material values of wildlife products. While based on our most up-to-date knowledge of the requirements of individual species, the program is drawn in its entirety to fit into the much larger picture of conservation of our natural resources as a whole. And it is our conviction that sound, well-planned conservation of all our resources is just as important during a war as it is during times of peace.

TIMBER IN WAR TIME

By W. J. Burton, *Assistant to Chief Engineer*
Missouri Pacific Railroad Company

The war has very greatly increased the use of timber. This increased consumption results not only from the construction of buildings and other items ordinarily made of wood, such as army barracks buildings, but also because of the substitution of wood for steel and other metals to a very considerable extent. The new cantonments have used lumber in unheard of quantities. The result of all of this tremendous demand has been that certain grades and kinds are now listed as critical materials. At the present time the bottle neck in production is the shortage of labor in the lumbering areas. An interesting sidelight on this labor shortage is the effect of rationing of meat. Lumber jacks are called upon for very strenuous physical exertion, which with the outdoor life, results in enormous appetites. It is reported that the normal meat consumption is no less than 15 pounds per man per week. Many men have left their jobs because of the attempts to hold them to the established ration. A special dispensation of not less than 10 pounds per man per week is being sought.

While the necessity for the greatly increased use of wood is to be deplored, and while it is unavoidable that things must be done in war time which are not in line with conservation, the situation is far better than it would have been without the benefit of the many conservation measures well established in the

industry. In other words, the situation might have been almost hopeless from the standpoint of the forest conservationist. It is quite otherwise.

Some of the war time uses for wood may be of interest. The earlier airplanes had wood frames, but for many years aluminum has been the material most used. The British, however, early in the war turned to spruce for their fighter planes because of the shortage of alumnium. More recently our own engineers have done likewise. The favored Sitka spruce is quite limited and the result has been the practical exhaustion of this valued material and the necessity of turning to noble fir, western hemlock, yellow poplar and maple. A somewhat similar substition of interest to us is that of Douglas fir and southern pine for the decking of war vessels, in place of the favored teak. The latter comes from India and the war has cut off the supply.

Pontoon bridges for the army engineers are being built of wood in place of the light metals, both because of the shortage of the latter, and because wood has certain advantages. Repairs at the front are more readily made and when such bridges are broken up by shell fire, the floating wood parts provide something to which the boys may cling.

An interesting development has been the use of steel grids to transform beaches or other flat areas into landing fields within a few hours. It has been found that rubber tires of air craft are very short lived when landings are made on these steel grids. This has resulted in the production of wheels of laminated hardwood, which wear much longer.

Within the last decade or so, what are known as timber connectors have come into rather wide use. These are steel rings, or toothed grids, which are inserted between the wood sticks of a truss or framework to form, with the bolts, a very much stronger joint than can be obtained with bolts alone. As the joint is usually the limiting feature in the design of a timber structure, these connectors permit equally strong contsruction with considerably smaller pieces of wood. Unfortunately, from the timber conservation standpoint, this type of wood construction is so efficient, that we see it used for many large structures to replace steel where otherwise only steel would have been possible of use. For example, some hangars for dirigible air craft have been constructed using wooden roof trusses and frames built up with these connectors. These hangars are 1000 feet long, 171 feet high and span almost a city block, or 237 feet. A large air craft factory near Chicago is almost entirely of wood. The wooden roof trusses give 150-foot clear span for the assembly

lines. It is estimated that these connectors permitted the construction of wooden structures in 1942 alone, which otherwise would have had to have been made of steel, to such an extent as to have saved over 400,000 tons of steel.

A somewhat similar development is also resulting in greater use of wood. The Forest Products Laboratory at Madison, Wisconsin, has assisted in the development of laminated glued wooden beams of considerable size. These beams are built up of many small pieces. Cheaper material may thus be used. Defects affecting strength, such as large knots, may be cut out. The beams may be shaped as arches or other forms to give the greatest utility from the least wood. It is possible to combine columns or posts into one piece with the roof beam or arch to form a very economical and quickly erected building.

Plywood also is in great demand. Its use for concrete forms not only requires less material to start with but the forms can be reused more readily, as the concreting progresses.

The practices so far mentioned tend to increase the use of wood in the war effort although some of them reduce the amount necessary, assuming that the structure would have been built of wood anyway.

At the St. Louis World's Fair in 1904 the Government exhibited a timber treatment plant in operation. This demonstration was under the direction of Dr. Hermann von Schrenk, who at that time was connected with the U. S. Forestry Service. This demonstration occurred at a time when timber treatment was almost unknown in this country. Very few engineers or architects of that time even knew of the cause of decay in timber or of the means of prevention. The exhibit had an important part in creating a treated timber consciousness in this country.

Among the largest users of forest products have been our railroads. They were among the first to use treated timber. Prior to the now almost universal use of treated cross ties, something approaching 200,000,000 were used every year to replace those which had decayed. This demand constituted a very serious drain on our forests. Far sighted railroad managers foresaw not only the danger to our forests but also an actual tie famine.

Steps intended to remedy the situation included the planting of trees along the railroad rights-of-way, the development of cross ties of something other than wood, and the preservative treatment of wood. Nothing came of the tree planting, probably because expert forestry advice was not obtained. Also, the substi-

tute tie is still to be developed. Efforts along this line began in England as early as 1840 and in this country in 1870, as shown by patents, but no such tie has ever lasted as long as the present day creosoted wooden ties. There are literally thousands of patents in the United States alone, but today informed railroad engineers know that it is practically impossible for such a tie to be developed and to succeed.

The use of treated ties has been so successful, that the average life has been increased from only about 8 years, to about four times as long, and better tracks, carrying heavier and faster trains, with much greater safety, now only require something under 50,000,000 ties per year. Today there is no thought of a tie famine.

During this same period, beginning about 1905, there has been much advance in lumbering methods and in the appreciation of good forestry practice. While there is much yet to be done, a great deal has been accomplished. There are many timber operators who are cutting on the perpetual basis and who consider timber a crop rather than an asset to be cashed in on as soon as possible. This is more particularly true in the southern pine areas of Louisiana and Arkansas. Much remains to be done in the way of modification of tax laws, to permit such growing of timber to be profitable to the owner. A great deal of educational work is bearing fruit, but much more is needed before uninformed local residents of our Ozark forests voluntarily discontinue the age old practice of burning the woods. Mr. Kelleter and others are doing a splendid job in this almost hopeless task here in Missouri. We may even hope for the day when a local resident caught stealing timber can be convicted in a local court. As far as I can find out, this has never happened.

To sum up, the cause of forest conservation has received a serious jolt because of the war, but the situation is not nearly as bad as it could have been without the advances made in the past third of a century.

The use of wood in place of steel is equivalent to increasing steel production by whatever amount is thus saved. As Americans first, we are glad our forests can make such a tremendous contribution to the all important early winning of the war, and we can take much comfort in the thought that, given half a chance, nature will regrow our timber, whereas, nature never replaces the coal or ores taken from our mines. We can also be very thankful that we have the forest conservation machinery set up and functioning and that the public attitude and understanding are better than ever before.

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Volume XXXI Number 4

Transactions of the

ACADEMY *of* SCIENCE

of Saint Louis

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Winslow M. Walker

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Robert McCormick Adams

Issued June 30, 1946

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I. INTRODUCTION

This report is the result of field investigations in New Madrid County, Missouri, carried on from April to July 1941 and from November 1941 to March 1942, a Work Projects Administration project, under the joint sponsorship of the Academy of Science of St. Louis and the Missouri Resources Museum. The Work Projects Administration of Missouri furnished all of the labor under the direct supervision of Winslow M. Walker and the general direction of Robert McCormick Adams.

The Work Projects Administration officials in both St. Louis and Jefferson City, Missouri were responsible for obtaining government funds without which the project could not have been carried out. Mr. A. C. Burrill, Curator of the Missouri Resources Museum, gave the official support of his institution to the project.

Thanks are particularly due to Mr. Joseph Matthews of Sikeston, Missouri for general permission to excavate on the property of the Matthews estate; to Mr. C. A. Critchlow of Matthews, Missouri, for allowing the excavation of a portion of his pasture; and to Mr. Howard Steel of Matthews who granted permission to work on the portion of the site extending onto his land. Mr. K. K. Baker of Sikeston furnished valuable aid in the locating of sites throughout New Madrid and neighboring counties.

Credit is due the people who conducted the technical aspects of the work. In this connection we must mention Mr. Edmund Winkler and Mr. John Arnold who took charge of the business arrangements of the projects; Mr. Frank for drawing the maps and features in the laboratory; Mr. Jay Sirolis and Mr. Ray Whisler for their photographic work; Mr. Harley Pritchett and Mr. Lloyd Willis for their efficient work as foremen; and Mr. Ben Ward for clerical work.

Betty Bachrach Adams was largely responsible for transcription of the manuscript. Ross R. Heinrich edited the final copy.

II. LOCATION AND PRESENT TOPOGRAPHY OF THE SITE

The site chosen for these investigations was located during a preliminary survey of portions of several counties in southeastern Missouri,[1] conducted the last week in March and the first week in April 1941, by Winslow M. Walker with the assistance of K, K. Baker of Sikeston.

The town of Matthews is situated about 13 miles north of the present course of the Mississippi River. The Matthews site lies north of the town in the northwest quarter of Section 31, Township 25 North, Range 14 East, half a mile west of the St. Louis and San Francisco Railroad tracks, and within sight of the Matthews High School (Plate I). The northern part of the land is now owned by Howard Steel and the southern part by the C. D. Matthews estate. The site occupies a position on the west side of Sikeston Ridge, overlooking a bottomland formerly known as West Lake, which is now drained by the Little River Ditch.

On the first high land east of the lakebed at a height of aboute 22 feet there are indications of a large prehistoric settlement extending for about one-third of a mile along the bluff and about the same distance back from the bluff. The remains of this large village site consist of numerous house circles; at least seven mounds varying from a few feet to 11 feet high; a low wall and ditch surrounding the principal mounds; and burial grounds.

In accordance with the procedure adopted for other Missouri archaeological sites[2 3] this one is designated as New Madrid County Location III, and this village site will be referred to in this report as NMv3. This site includes mounds numbered NMo10-16. The details of the topography of NMv3 are given on Plate III. As can be seen from this map, NMv3 extends for some 650 feet north into the Howard Steel farm and some 850 feet south into the C. D. Matthews estate. A portion of the C. D. Matthews estate is a sloping pasture on the west side of the field farmed by C. A. Critchlow. In the Critchlow pasture is the remnant of a large sassafras stump more than four feet in diameter, which appears to be 150 to 200 years old (Plate IV). The soil around it has been left as a little hummock after the erosion of the rest of the slope by several gullies. The largest and newest of these gullies extends southeasterly up the pasture slope and about 200 feet into the cultivated wheat field. This deep gulley was formed, we have been told, in 1911-12, and along the margins there are evidences of burials with accom-

panying pottery and artifacts which have washed out and down the slope from time to time.

About fifty feet north of here is another shallower gulley where more pottery has been found, and 150 feet farther north is the outline of an older gully. There are also two small narrow gullies which drain the southwest part of the pasture near the old stump. North of the Steel-Matthews fence, erosion gullies are not so well developed, although at some 675 feet north of the fence line there is an incipient small gulley. This small gulley marks the end of the ditch outside the old village embankment.

III. SUMMARY OF PREVIOUS WORK

This site was first described in 1880 by W. B. Potter in a memoir published by the Academy of Science of St. Louis. In his description he refers to this site as "Settlement A."[4] Plate C of Potter's memoir (reproduced herein as Plate II) shows a plan of a portion of the settlement lying within the enclosing low embankment. This portion of the settlement measures some 1500 by 800 feet. Potter's description of the site is reprinted below, together with the corresponding designations used in the present publication.

> Settlement A.—The northern settlement (Plate C), on the West Lake, is about thirteen miles above the town of New Madrid on the edge of the swamp. The bluff rises about 22′ above the present water level in the swamp, and is quite steep. A wall and ditch surround the settlement, the former of which is 3′ to 3′ 6″ high and the latter 18″ to 2′ deep. The most prominent mount (A) (present designation NMo10) is that marked (33) (Plate C), placed on the edge of the bluff. It is elliptical in plan, 110′ by 70′ in diameter at the base and 11′ high. The long axis of the mound is parallel with the swamp. Excavations have been made on this mound, but nothing of importance was discovered.
>
> The mound (B) (present designation NMo12) marked (29) is one of the burial mounds of the group. It is a low flat mound of circular outline, 90′ in diameter and 7′ 6″ high. From this mound a number of skeletons and a large quantity of pottery have been obtained from the north and east sides, the south and west sides seeming to be almost barren of remains. Col. Croswell, who devoted some time in excavating this mound, states that "There appeared to have been observance of order in depositing the dead in this mound. . . . The skeletons were often with the feet

as the head to the centre, and were lying on the back, on the face, on the right side and on the left, and in two instances appeared drawn up as if in sitting posture (flexed?). As the first skeletons were uncovered on the outer margin, they were found lying side by side with a covering of about 14″ of earth. The next layer immediately above was advanced a little nearer the centre. Then followed others in the same order, until finally they were were found lying six deep, the bones much decayed, separated and broken, and mingled together in a mass interspersed with sand which had covered them."

The other burial mound (C) (present designation NM°14) marked (31), at the corner of the cultivated field of Mr. I. S. Brey, is a low flat circular mound, 120′ in diameter and 9′ high. A number of skeletons and much pottery have been taken from this mound also. Col. Croswell states that "a skeleton was found extended at full length on the back, with the skull resting upon a stone weighing sixteen pounds. The stone is a smooth drift boulder of quartzite, having at one side, which lay uppermost, nearly a flat surface with an artificial depression in the centre. It resembled the old fashioned lapstone used by shoemakers. (Anvil?) Another singular form of burial discovered in this mound, was that of skeleton extended on the back, with the skull resting in a shallow dish, the side next the shoulders having been removed to accommodate the head and neck, and keep the whole on a level. During the examination of the mound a hearth was exposed, covering a space of about 12′ square, in the immediate vicinity of which, three vessels were discovered which had contained yellow and red paint."

The second mound (D) (present designation NM°13) marked (29) is circular in plan, 60′ in diameter and 7′ high. This was probably also a burial mound, but very little work has been done in excavating it.

There are two small mounds (E, F) (present designations NM°16 and NM°11) marked (25 and 27) 3′ and 4′ high respectively, and each 16′ in diameter. No excavations have been made in them.*

The circular depressions are well marked at this settlement. They occur all over the settlement, with the exception of an oval space near the large mound, as far as the cultivated field on the south side, in which all traces of the settlement are lost. A few depressions may be seen south of the corner of the field along the edge of the bluff, and

probably the southern limit of the settlement is not far from this place. The field extends south a quarter of a mile and beyond it, in the woods, some imperfectly defined depressions occur; but there is no trace of a wall or a ditch near, and it is not probable that these are connected with the settlement on the north side. The depressions have an average depth of 27″ in the centre and a diameter of 30′. There is no definite arrangement in the placing of these depressions, as may be seen in the plan. The square of baked clay occurs generally in the centre, but is often found on one side and at a depth of about 15″. The square is 32″ by 27″, about 3″ thick, and the upper surface is much more baked than the lower. It is stated by the farmers residing near, that in the ridges between the depressions "digging nearly always discloses human and animal bones, but no pottery."

A sink occurs on the east side in the line of the wall and ditch, which may mark the place from which the earth was taken to build up the mounds. A growth of large timber covers the settlement at present (1878), and includes such trees as sycamore, elm, maple and a few oaks. Some of these trees are 2′ to 3′ 6″ in diameter and are to be found growing on the mounds or in the depressions.

Potters' plan (Plate II) and his description served as the point of departure for the present operations. First of all an attempt was made to identify all the features recorded in the early plan by evaluating the results of the intervening sixty years of erosion, pitting, and plowing of the site. In this connection a gulley shown on Potter's map (Plate II) was used as one clue in the relocation of the site, although only an outline of this old gulley remains today (Plate III).

IV. METHODS AND TECHNIQUES

In order to facilitate the locations of excavations, grid systems were established. In the south half of the village a giant east-west north-south grid system was set up. A 00 point (stake) was located at the intersection of an east-west line and a north-south line running midway between the wheat field and the western boundary fence. All test trenches were given individual grids but the zero point (stake) of each (located at the southeast corner) was tied in to the larger grid. Since the north half of the site was not excavated until several months later, a new grid was determined for this area. In this case the fence separating the Steel and Matthews properties was

used as the east-west cross line with the north-south base line extending north from the fence over the center of the mound NMo10. A nail head on the south root of a 24 inch elm in the fence row between the Matthews and Steel estates was used as a bench mark for relative elevation.

Three different methods were employed in excavating the Matthews site: vertical slicing, horizontal stripping, and test trenching.

The vertical slicing technique was particularly useful in obtaining a cross section profile of the village in the gulley area and in excavating the burial mound.

Horizontal stripping was resorted to in all areas where house sites were encountered. House sites were excavated by stripping down from the surface in six inch layers in order to disclose complete floor patterns. Moreover, the six inch level system was used for recording all miscellaneous material.

Test trenching was used in excavating the large ceremonial mound and in other areas where it was necessary to determine sterile depth or internal structure. Throughout the site, that technique was employed which might best reveal the exact position, location, and depth of all archaeological features and objects.

V. RESULTS OF EXCAVATIONS

Test Trenches

A series of seven test squares (numbered T1 to T7 on Plates III and IV) were first dug along the north-south base line at the foot of the slope at the south end of the village. These trenches revealed quantities of miscellaneous flints, animal bones, burnt clay, and potsherds, all apparently in secondary position. A total of 116 vessels was indicated by the rim sherds alone.

A second line of test pits (numbered T8 to T13) was dug near the margin of the wheat field. Results of these tests in the undisturbed portions of the village were as follows: flints were most abundant at the surface, diminishing to level 3. Bones were most abundant at level 3, diminishing to level 6. Burnt clay was most abundant at level 4, diminishing to level 6. Plain shell tempered ware was most abundant at the surface, diminishing to level 6. Decorated grit tempered ware was abundant at level 2 and 4, decreasing to level 6. Materials from T14 and T15, located on the slopes of the deep gulley, were listed with the surface remains as of unknown origin.

Test pits T16 to T35 were scattered about at various points in the northern section of the village. While these test trenches

were mainly for purposes of exploration, T16 was expanded to about thirty times its original size when indications of two house sites were found. In this section sterile soil was reached at level 5. Shell tempered potsherds outnumbered grit tempered four to one, but both were found at the same depths.

House Sites

Evidences of 9 houses were uncovered in the south end of the village, and 10 in the north end, but portions of their floor plans had been destroyed by gulley erosion. Complete plans, however, were obtained from excavations at T9 and T16 (House Sites F1) and excellent cross sections were found at T14 (House Sites F2, F3, and F4).

The surface indications of the house sites, as recorded by Potter in 1878, were the circular depressions averaging about thirty feet in diameter and two feet in depth. By 1942 these depressions had been largely plowed over, but dark stains of ash and charcoal could still be seen on the plowed surface. Just below the plow line at a depth of about six inches the outline becomes more distinct and begins to assume a more nearly rectangular shape as the layers are stripped. At a depth of about two feet the floor plan of the structure becomes apparent (see Plates V-A, V-B, VI-A, and VI-B).

A double row of small postmolds form the wall outline. There is an interior circle of larger posts and a central fireplace. The only doorway faced south or west toward the old lakebed. Large refuse pits were found outside the structure but smaller ones were inside. The walls were probably of wattle and daub, averaging about one foot thick, plastered between the two lines of small wall posts. The posts in each line were set about 5 or 6 inches apart. Cross beams were attached to the main uprights spaced about every foot vertically. Sometimes the wall posts were not set in trenches but were evidently set up in a not too straight line. Positive evidences of roof material were scarce, but it was likely thatched with a large smoke hole in the center.

The excavation of T9, F1 was particularly fruitful. This house plan measured 22 by 18 feet with its long axis parallel to the ridge. Within this house there was a line of small posts, possibly marking off a partition or supporting a bench. The fireplace in this house was especially interesting. It was oval in shape with raised rims of puddled clay elongated at the west end to give a maximum length of 6.2 feet and width of 4 feet. The rim, which had a rounded edge, was 9 inches thick. About 2 cubic feet of unadulterated white ash was found in this fire-

place, indicating complete combustion of a considerable amount of material.

Artifacts and pottery were abundant in T9, F1; small arrow points of both flint and bone, knives, spear points, drills, chisels, hammer stones, and grooved tool-sharpeners were found. There were bone awls, needles, flakers, and ornaments. In addition to the ordinary jars, bowls, bottles, plates, and pots, a "juice press" was found in place in the southeast corner. Other objects of pottery including trowels, spindle whorls, discs, ear plugs, effigy vessels, and a pipe came from different places in the house site. Other house sites contained similar materials but their fireplaces were less elaborate.

House sites in the north end of the village were similar structures, but at deeper levels they showed wall posts set into trenches which left definite dark stains in the yellowish clay. Numerous postmolds, both inside and outside the dwelling, probably indicated interior furnishings, drying racks, etc. A polished greenstone spud was discovered near two large postmolds outside the southwest corner of T16, F1. This might have been used in the dressing of hides and skins.

In the low mounds NM°11 and NM°16 evidences of house structures were found at several levels extending from only a few inches to as much as 5 feet below the surfaces (Plate IX-B). Although the structure nearest the surface in NM°11 was partly disturbed by the plow, there was evidence that it had been destroyed by fire. The bones of a human skeleton, probably those of the occupant, were found just underneath the charred timbers at the northeast corner of the structure. At a depth of two feet there was a stratum of water-laid sand, and below this a series of overlapping house patterns, indicating a period of village occupation prior to the building of the mound. However, the pottery and artifacts did not suggest any component difference.

A glance at Plate IV will show the concentration of house sites in the excavated area. Assuming that this was the degree of concentration over the entire village, and that all houses were occupied at the same time, a rough estimate of the aboriginal population can be determined. There were at least 10 houses visible in Plate IV in an area which is about 1/36 of the total area inside the village fortification, excluding the sink and ceremonial areas; so there must have been at least 300 to 350 houses in the occupied area. If the number of persons occupying each dwelling averaged 5 and all the structures were inhabited simultaneously, the total population of the village would have been over 1500.

Ceremonial Mound

The large mound NMo10 on the bluff edge overlooking the lakebed proved to be the most unusual of all the sites excavated. The excavations of 1941-42 were confined largely to the southwest and northwest quarter of this mound, the remainder being purposely left for later investigators.

Cross trenches through the long and short diameters revealed the existence of an inner truncate quadrilateral mound 15 by 35 feet (Plate VII). At the top of this inner mound there was a central fireplace which was probably ceremonial in purpose (see Plate VIII). On the east and west sides of the base of this inner mound a trench or ditch had been dug and this trench had contained posts which could have formed either a palisade or the supports for some kind of structure over the mound. Swallow[5] reported finding a similar structure inside the great mound of the Lilbourn group farther south along the same ridge in 1856.

Gummy gray-blue clay was found on the west side and top of the inner mound, indicating that another building period followed the completion of the inner truncate structure. On the top of this clay, postmolds were found indicating the remains of a later structure. The final period in the mound's construction raistd it to a height of at least 11 feet as it was found in 1878. At that time it had an elliptical contour 110 feet to the north and south by 70 feet to the east and west. Since 1878 the mound has been cut down more than 5½ feet and the displaced earth has been spread down the slopes. A crevice 40 feet long was discovered extending along the west side in the gray clay. This might have been caused by the New Madrid earthquake[6] of 1811 or perhaps some earlier tremor.[7]

Thirty-six artifacts were taken from this mound, consisting of arrow points, spear points, knives, drills, chipped celts, hammers, sharpeners, polishers, and one bone awl. Spear points were the most numerous class of objects. One of them resembled, but was shorter than, the Scotts-Bluff Yuma point. A large narrow chipped celt with one flat surface might have been an adz for gouging out log canoes. Both shell tempered and clay-grit tempered pottery were encountered in the fill with some 20 ceramic specimens. Most unusual of these were 7 small biconical objects of unknown use (see Plate XIX). Two pottery vessels were found intact on the northwest section of the mound near the remains of an intrusive burial which had been disturbed by the plow. One small cup or dipper in the shape of a Busycon Shell was found at the top of the inner mound

south of the fireplace. This suggests the possibility of either a southern origin for the tribe or at least contact with the peoples of the Gulf Coast.

On Potter's map of 1878 the space in the center of the mounds was shown as being free from house pits. To check this, test trenches T17, T18 and T20 were dug between the mounds. While indications of village debris, sherds, flints, etc., were found to a depth of three levels, there were no signs of house outlines. It is believed, therefore, that this region constituted a special sacred ceremonial area or plaza, as has been commonly reported for mound groups farther down the Mississippi Valley.

Village Wall or Stockade

The outer edge of the village was the final area investigated. The sink (see Plates II and III) was discernible as a feature of the topography. What appeared to be the remains of a breastwork was found below plow line in the form of a hard clay ridge averaging about 7 feet wide with a double row of postmolds on top (see Plate IX-A) indicating the former existence of a stockade. Outside the wall there had been a ditch or moat and the earth thrown up to form a ridge roughly 3½ feet high. At the northeast corner the postmolds followed the gradual curve of the clay ridge (Plate X). At the edge of the sink all features of the wall stopped and then commenced again on the south side. This might have been a gap for a gate on the eastern side of the village. The evidence of a wall and palisade enclosing three sides of the village suggests the need of defense against hostile tribes.

Burial Areas

In the village site 4 small burial areas were found adjacent to the houses, 3 in the south end and one in the north. These appeared to be small family plots, as no more than 4 skeletons were found in any one plot.

Burial NMv3-1 was between house sites F2 and F3 and consisted of the skull of a child found on the edge of the gulley bank at F14 at a depth of one foot. The rest of the skeleton had probably been washed away down the gulley. Near this skull was a small two-handled pot with lugs (P63).

Another burial area (designated as F13), containing a single skeleton, was located outside of house sites F8 and F12. The single burial NMv3-6 was found at a depth of 1.5 feet and consisted of the semi-flexed skeleton of a young person, probably

female (see Plate XI-A). Lying on the skeleton were two clam shells, possibly used as spoons, and near the head was an inverted bowl of plain, dark, polished shell tempered ware (P45).

Near the head of the deep gulley there was uncovered a burial plot at F10 containing the bones of four skeletons (see Plates XI-B and V-C). These were all laid out at full length with the feet of NMv3-2 resting on the head of NMv3-5 directly beneath it. NMv3-2 was an adolescent male and NMv3-5 an adult female. At the head of the latter were a bowl (P16), a deer bone, a bottle (P17), and a pottery smoothing stone under the left ear. These burials were so close to the surface that the plow had struck and shattered the tops of the vessels. Just south of NMv3-5 lay another skeleton, NMv3-3, an adult female extended with the head to the east. At the back of the head was a water bottle (P15). Part of the left side of this skeleton had been lost, presumably by erosion. NMv3-4 was still nearer the edge of the gulley. The skull was missing and the burial was too badly destroyed to record.

Another small burial plot was found outside the northwest corner of house F1 in T16. There had been two burials, one a male, the other a female. The male skeleton, which was badly disturbed, lay at a depth of 1.5 feet and had no associated objects. The female was half a foot deeper and was accompanied by a bottle on one side of the head and a bowl, small cup, and notched shell spoon on the other side (see Plate XII-A). All the vessels were plain, shell tempered ware. The spoon was too friable to save.

Burials were also found in two of the house mounds NMo10 and NMo11. In NMo10, the ceremonial mound, the burials were intrusive bundles into the upper level of the northwest quarter. One burial showed nothing but scattered bones associated with two small shell tempered pots with handles. As noted before, in NMo11 human remains, which were much disturbed, were found covered over by the charred remnants of a dwelling just below the plow line. There was no apparent grave and the bones could be those of the occupant who might have perished in the collapse of the structure. The low four foot mound had been heaped over this dwelling, thus indicating, perhaps, some social rank for the deceased. In one of the lower level house patterns of NMo11 the bones of a tiny infant or foetus were found in a small pit of the floor. This might have indicated the practice of infanticide, as nothing but refuse was found in the pit.

NMo12 was a true burial mound with dozens of burials laid

in tiers throughout the pile. According to the 1878 account, as many as 6 were piled on top of one another at the center. This site had been so thoroughly dug over that our work failed to discover a single undisturbed skeleton, although a couple of unbroken vessels, a bowl, and a pot, and a handful of other specimens were recovered. One of the disturbed skulls had evidence of occipital flattening, perhaps as an indication of social rank (see right hand figure in Plate XII-B). This was the only site which yielded true painted pottery, some sherds of a red and white design being discovered. A ware with a red slip was rarely encountered in the village test pits.

A summary of burial data for the Matthews Site is given in Table I.

VI. DESCRIPTIONS OF SPECIMENS

Artifact Analysis

The 288 artifacts found at the Matthews site fall into 3 main categories—stone, flint, and bone, although evidences of the use of shell, galena, and cannel coal were also found.

The stone artifacts are crude, heavy, unground specimens such as hammers, anvils, metates, mullers, and grooved sandstones used as tool sharpeners. Ground stones comprise celts, puds, polishers, and discoidals (Plate XIII-B).

TABLE I

PROVENIENCE OF BURIALS

Site	Number	Location	Description
NMv3	1	T14,F14	Near house sites F1 and F3; crushed child skull, other bones washed out; 1.0′ deep, small pot P63 near head.
NMv3	2	T15,F10 Sq2	Young male head extended west; 0.6′ deep; on top of burial 5 with feet in bowl by head of 5.
NMv3	3	T15,F10 Sq2	Adult female head extended east; 0.55′ deep; water bottle P15 by right shoulder; near burials 2 and 5.
NMv3	4	T15,F10 Sq1	Near burial 3; 0.3′ deep; mostly washed away.
NMv3	5	T15,F10	Beneath burial 2; 1.0′ deep; adult female, head extended east; bowl P16, bottle P17 by head, small smoothing stone under left ear.
NMv3	6	T15,F13 near F7	Near house site F8; 1.5′ deep; young female, semiflexed, head northeast; bowl P45 overturned near head, 2 shell spoons.
NMv3	7	T16,Sq OR7	Near house site T16,F1; 2.0′ deep; adult female, head extended southwest; bowl P108, bottle P109, cup P110, and shell spoon.
NMv3	8	T16,Sq OR6	Near house site T16,F1; 1.5′ deep; adult male, extended southwest; badly disturbed.
NMo10	1	Sq5OR5	Upper level ceremonial mound intrusive; 1.0′ deep; scattered bones disturbed by plow; small bowls P9 and P10.
NMo10	2	Sq556OR5	Upper level ceremonial mound intrusive; 1.0′ deep; bundle, pile of bones skull on top; adult female.

(Continued)

TABLE I (CONTINUED)

Site Number	Location	Description
NMo11 1	SqOR2	Adult male (?), extended, very disturbed; 1.3′ deep; debris of burned house in upper level; possible victim of violence; no burial mound.
NMo11 2	Sq(–5R3)	House floor F7; lower level site under mound; 3.5′ deep; infant, possibly foetus, in floor pit; No associations.
NMo12 2	Sq3OL1	Adult male skull, disturbed; 1.5′ deep; in burial mound, flexed (?); potsherds.
NMo12 2	Sq15L1	Disturbed burial, no skull; 0.5′ deep; in burial mound, flexed (?).
NMo12 3	Sq2OR2	Disturbed burial, no skull; 1.0′ deep; in burial mound.
NMo12 4	Sq15R3	Disturbed burial, adult male, head east (?); 2.5′ deep; bowl P4, pot P5; in burial mound.
NMo12		Many burials with much pottery excavated in this mound in 1878.
NMo13		Probably a burial mound—not dug.
NMo14		Large burial mound excavated in 1878. Source of much pottery.

Chipped flint artifacts include 77 small arrow points, both triangular and notched-stem forms with fine chipping, some of which are serrated; 3 hoes and fragments of several more; 9 chisels; 14 celts; and several rechipped scrapers (Plate XIII-A).

Bone artifacts comprise 9 awls, 4 of them made from deer ulnae; 17 antler tip flakers; projectile points; 3 needles, 4 cylinders; one large carbonized astragalus bone used as a polisher; and a few cut bones used as ornaments; one piece of cannel coal showing use as a polisher, and a cube of galena which may have been used as an ornament. A small gastropod sea shell may have been an ornament, and clam shell spoons were found with several burials. (Plate XIII-A)

The largest celt measures 4.75 by 2.25 inches and was found at a depth of 1.3 feet in house F9. The smallest celt, found at a depth of 1.8 feet in house T16, F1, measures 2.5 by 1.25 inches. Several chisel celts are of flint, evidently rechipped from broken

hoe blades. One large specimen, 7 by 2.25 inches, with one flat surface, may have been an adz. Two complete hoe blades with flaring bits were found in the bottom of house F2 at a depth of 2.8 feet. They were standing together with their cutting edges up and displayed a high polish as a result of their use for digging. The third hoe, which measures 9.5 by 4.5 inches, has a pointed bit and was found in the north end of the village. Certain other chipped flint forms had apparently been made from older, concave base, side-notched forms and were used as chisels or scrapers. The technique indicated by the small triangular and notched stem points is the fine chipping of flakes or thin blades characteristic of the Middle Mississippi Phase.

The flints range in color from white through shades of yellow, brown, pink, red, gray, blue to black, but no obsidian and little translucent material was found. With the exception of one polished needle with an eye near the larger end, the bone artifacts are not distinctive. Two other needles were also discovered made from deer ulnae or slivers of leg bones. Antler tip flakers are numerous and there are a few straight tips with hollow bases, suggesting their use as projectile points. Part of a polished animal jaw, which may have been used as an ornament, was unearthed.

Two or three aberrant forms were found. One, a spear point of gray-brown, finely chipped flint, resembles, but is shorter than, the Scotts-Bluff Yuma point. It came from the first level of NM010 near the top of the mound. Another point of gray flint with concentric ring structure has the lozenge shape with expanding base which is more typical of the atlatl dart points of the Bluff Dwellers of the Ozarks.[8] It was found at a depth of only 1.2 feet near the edge of a gulley. One large spear point of bluish flint speckled with gray has the characteristic outline of the Illinois Black Sand point. It was found less than one foot deep in a large house site in the Matthews village.

These artifacts are suggestive of the activities of a primitive hunting, fishing, and farming people.

Pottery Analysis

Dr. James B. Griffin of the Ceramic Repository for the Eastern United States analyzed all of the ware types from the Matthews settlement. He found seven wares that were shell tempered and one ware that was clay tempered. Plain, undecorated, shell tempered and clay-grit tempered potsherds outnumbered the decorated sherds two to one. Decorated sherds

showed a majority of cord-marked designs with a minority of incised, trailed, and punctate designs.

Middle Mississippi Plain is the most common shell tempered ware in the site. This type is found in jars, bottles, effigy, bottles, effigy flange bowls, bowls, cups, and figurines (Plate XIV Nos. 1, 2, 4, 7, 12). Human effigy and conch shell effigies were also found. The ware is of medium thickness (5-10 mm.). The smaller jars have 2 to 4 loop or strap handles and several have lugs with vertical perforations. The ware has a rather coarse texture and the hardness varies from 2.5 to 3.

Some of the jar sherds with outward flanging rims have incised rectilinear and curvilinear designs running around the shoulder area (Plate XV). This ware is more porous and softer than the Middle Mississippi Plain ware and has been named Matthews Incised.

Many sherds from plates, effigy flange bowls, scalloped bowls, plain bowls, and bottles have a dark gray polish on the surface and have a hardness of around 3 (Plate XIV 5, 6, 8, 9, 11, 14). This Bell Plain ware sometimes has trailed designs on the rim upper surfaces and bowl flanges (Plate XVI Nos. 10, 11, 15).

A few sherds are relatively thin and are red filmed. They are classed as St. Francis Red Filmed and appear to be only from bowls in the Matthews settlement.

A few polychromed red and white sherds were found at burial mound NM◦12. Many complete bottles of this St. Francis Red and White ware were excavated by the 1878 Academy Expedition (4).

A number of thick, poorly fired sherds of coarse texture were unearthed in the village. Their only form was that of a deep, straight-sided bowl with a hole in the bottom, popularly called "juice presses" (Plate XIV No. 3). Some of these were incised with curvilinear trailed designs near the base (upper middle photo Plate XV).

Two or three thick, poorly fired sherds from large shallow bowls or "salt pans" were identified as Kimmswick Fabric Impressed Ware.

While Middle Mississippi Plain ware was the most common, clay tempered ware was abundant. The latter ware had a hardness of about 3 and a surface marked with cord wrapped paddle impressions. This Korando Cord Marked ware was probably largely utilitarian, as it was not found with burials and was broken into smaller sherds than the shell tempered ware. Both the shell tempered and clay tempered wares were evenly dis-

tributed horizontally and vertically in the village. Moreover, there was no apparent stratification of shell tempered and Korando Marked wares.

Human, frog, bird, and animal forms were encountered in the effigies unearthed in the Matthews settlement (Plate XVI, Nos. 1-8 and Plate XVII). Most of these were of Mississippi Plain ware (except 6-8 of Plate XVI and 2 and 9 of Plate XVII).

Plate XVIII-A shows restored burial pottery.

Plate XVIII-B shows restored pottery from the village. Tall necked water bottles are absent from the village, indicating that this form had only a burial function. Moreover, it was the only form found with colored decorations. Plate XIX shows miscellaneous pottery objects which were shell tempered with coarse shell particles. These objects included discs, spindle whorls, small mushroom shaped "ear plugs," elbow pipes, and large bifurcated and conical-ended pottery trowels.

Faunal Remains

Deer bones are abundant in the village refuse pits. All parts of the animals from the antlers to the hooves were found. Most of the long bones of the fore and hind legs were split longitudinally, presumably to extract the marrow.

The bones of carnivores were also common. One large canid jaw, probably of a wolf, and several smaller canid jaws of varieties of dog or fox were found. Large carnivores, such as bears, panthers and lynx, were not found in the excavated area. In house site F16 the bones of bison were plentiful but they were not found elsewhere.

A few beaver jaws and incisor teeth were excavated, as well as remains of other rodents such as squirrels and rabbits. Bird bones were common and included turkeys, ducks, geese, and herons. Some turtle and fish remains were found.

Vegetal Remains

Small-grained corn, acorns and hickory nuts, showing evidence of roasting, were found in refuse pits. Although no direct evidence was found of beans, gourds, and squashes, the squash shape of some of the bottles may be considered as indirect indications of the latter.

VII. TRAIT ANALYSIS OF THE MATTHEWS SITE

Table II contains a summary of the traits for the New Madrid Focus. This list is based on Potter's summary of the 4 New Madrid County sites and one in Scott County together with the results of the recent excavations at the Matthews Site.

Table III gives a comparative trait list for the New Madrid, Kincaid,[9] Gordon,[10] and NE-Ark[11] foci, which are located in the same general geographic region. As can be seen, there is a high correlation of the traits of the 3 other foci with those of the Matthews Site. It seems justifiable to place them all in a common aspect. Since this aspect seems to center around the junctions of the great rivers of the Central Mississippi Valley, the term "Centroval" could be used for designating this aspect.

Table IV lists the major traits of the stone grave complex found east of the Mississippi in both the Kincaid and Gordon foci, but which seemed to be lacking west of the Mississippi in the New Madrid and NE-Ark foci. While these traits may be diagnostic for the establishment of East Centroval and West Centroval aspects, it seems preferable to await more data before setting up a new aspect.

Study of the data of Tables II, III, and IV has resulted in a tentative assignment of the Matthews Site to the Mississippi Pattern, Middle Phase, undetermined aspect, New Madrid Focus. With the exception of cord marked, grit tempered pottery associated with the shell tempered wares, there is almost no evidence ofthe Woodland Pattern. Virtually all other diagnostic traits are recognized as belonging to the Mississippi Pattern, Middle Phase.

A possible influence from the Upper Mississippi Phase is to be noted in the characteristic form of incised pottery decoration by trailing, broad-line incising, and punctating designs, and possibly in the discovery of perforated flat bone needles.

With regard to the aspect the problem becomes more complicated, the configuration of the mounds, village, and associated features is common all the way down the Mississippi Valley. Moreover, there are resemblances to the Plattin Focus sites in Jefferson County, Mo., the Kincaid site on the Ohio River near Metropolis, Ill., the Gordon-Fewkes site of the Tennessee-Cumberland Valleys, the King Mounds at Wickliffe, Kentucky on the Mississippi, and numerous sites in the lowlands of Eastern Arkansas as far as the Arkansas River.

TABLE II

TRAIT LIST FOR THE NEW MADRID FOCUS

A. VILLAGE TRAITS

a. Mounds and house pits surrounded by earthworks and ditch; located on banks of ancient watercourse.
b. Open plaza near center surrounded by mounds—probably for ceremonial use.
c. One or more large ceremonial mounds often truncate.

B. HOUSE TRAITS

a. Circular house pits about 30 feet in diameter.
b. Depressed rectangular floor plan.
c. Some walls set in trenches.
d. Wattle and daub wall construction between inner and outer row of small posts. Larger interior posts.
e. Central fireplace. One house site with puddled clay fireplace with raised rim.
f. Doorway generally facing watercourse.

C. BURIAL TRAITS

a. Burials in low rounded mounds.
b. Burials in small plots of shallow pits outside houses.
c. Flesh burials in extended or semi-flexed positions.
d. Grave goods present with burials.

D. CERAMIC TRAITS

a. Large jars with wide or narrow mouths, shell tempered,
b. Bowls, finely shell tempered, polished dark ware, deep to shallow, curved or sloping sides, flat or rounded bottoms, 4 or 6 points scalloped rims, plain or incised decoration, effigy flanges.
c. Bottles, thin finely shell tempered polished ware, globular to flattened globular body shapes, long and short necks, some effigy shapes, few painted.
d. Plates, shell tempered dark polished ware, deep or shallow with wide flat rims and rounded or flat bottoms, often incised with effigy flanges.
e. Small to tiny globular shell tempered unpolished pots, with and without handles, lugs, and flanges.
f. Large utilitarian grit tempered vessels, bowls, jars, platters, and possibly "salt pans"; surfaces cord or fabric impressed.
g. Large "juice press" jars finely shell tempered or clay-grit ware; large orifice at one end and small one at opposite end; smoothed but unpolished, undecorated or incised surface.

(Continued)

TABLE II (CONTINUED)

h. Spindle whorls made from perforated potsherds.
i. Discs, unperforated.
j. Trowels with rounded or bifurcated handles.
k. Elbow pipes, plain and effigy forms.
l. Small mushroom-shaped earplugs.
m. Human and animal figurines.
n. Pottery more abundant than artifacts.
o. Unidentified biconical objects.

E. ARTIFACT TRAITS

a. Stone hammers, anvils, manos, metates, shallow mortars, pestles, tool-sharpeners, and polishers; crude, heavy and little-worked.
b. Unpolished biconcave discoidals.
c. Polished celts and spuds.
d. Chipped celts or adz.
e. Small finely-chipped isoceles triangular points.
f. Small side-notched arrowpoints.
g. Hoes; chipped flint, bell-shaped and pointed bit.
h. Chisel celts; narrow chipped.
i. Knives and scrapers re-chipped from older implements.
j. Drills; straight and winged base types.
k. Flake knives with chipped edges.
l. Deer ulnae and tibiae awls.
m. Split bone needles.
n. Bone cylinders with blunt ends.
o. Antler tip flakers.
p. Antler tip points with hallowed out bases, possibly projectile pointts.
q. Polished animal jaw ornament.
r. Galena cube.
s. Gastropod (sea) shell.
t. Engraved Busycon shell ornaments.
u. Cannel coal ornaments.
v. Columella shell beads.

F. MISCELLANEOUS TRAITS

a. Large quantities of deer bones in refuse pits.
b. Small-grained corn.
c. Hickory nuts.
d. Figurines show ceremonial head dress and hair ornaments.
e. Jaws of small dogs common in refuse.
f. Charred acorns.
g. Bison bones.

TABLE III

COMPARATIVE TRAIT LIST*

Traits	New Madrid Focus Matthews, Mo.	Kincaid Focus Kincaid, Ill.	Gordon Focus Wickliffe, Ky.	NE-ARK Focus Pecan Pt. Ark.
I. VILLAGE DETERMINANTS				
a) Group of mounds, house pits earthwork surrounded by embankment	x	x	0	0
b) Open space, probably ceremonial	x	x	x	x
c) One or more large ceremonial mounds often flat topped	x	x	x	x
d) Low rounded burial mounds	x	?	x	x
TOTALS	4	3-1?	3½-½?	2½-½?
II. HOUSE DETERMINANTS				
a) Circular pits averaging 30′ diameter	x	?	?	x?
b) Depressed rectangular floor plan	x	x	0	?
c) Central fireplace	x	x	x	?
d) Large interior posts	x	x	x	?
e) Puddled clay fireplace, raised rim	x	?	x	?
f) Wattle and daub wall construction	x	x	x	?
g) Plaster between inner and outer row of small posts	x	x?	?	?
h) Division of house interior	x	?	x	?
TOTALS	8	5-3?	5-2?-10	1-7?
III. BURIAL DETERMINANTS				
a) Mound burials	x	x	x	x?
b) Burials outside of houses	x	x	x	x?
c) Extended in flesh	x	x	x	x
d) Grave goods accompanying burials	x	x?	x	x
TOTALS	4	3-1?	4	3-1?

(Continued)

TABLE III (CONTINUED)

Traits	New Madrid Focus Matthews, Mo.	Kincaid Focus Kincaid, Ill.	Gordon Focus Wickliffe, Ky.	NE-ARK Focus Pecan Pt. Ark.
IV. CERMAMIC DETERMINANTS				
a) Coarse shell tempered ware	x	x	x	x
b) Fine shell tempered ware	x	x	x?	x
c) Plain grit tempered ware	x	x	x?	x?
d) Cord impressed grit tempered ware	x	x?	x	?
e) Clay tempered ware	x	x	?	?
f) Water bottles	x	x	x	x
g) Juice press jars	x	x	x?	?
h) Salt pans	x	x?	x?	?
i) Effigy ware-relief, head, flange	x	x	x	x
k) Scalloped rim vessels	x	x	x	x?
l) Relief decorations	x	x?	x	x
m) Four-handled vessels	x	?	x	?
n) Figurines	x	?	x	x?
o) Trowels	x	x	x	x
p) Spindle whorls	x	x	x	x
q) Discs	x	x?	x	x?
r) Elbow pipes	x	x?	x?	x
s) Mushroom-shaped ear plugs	x	x?	x?	x
TOTALS	19	17-2?	18-1?	14-5?
V. ARTIFACT DETERMINANTS				
a) Small finely chipped isosceles projectile points	x	x	x	x?
b) Small finely chipped notched stem points	x	x?	x?	x?
c) Large bell-shaped chipped hoes	x	x?	x	x?
d) Chisel celts, chipped	x	x	x	x
e) Straight drills	x	x?	x?	?
f) Antler projectile points	x	x?	x	?
g) Blunt bone cylinders	x	?	x?	x
h) Unpolished discoidals	x	x?	x?	x
i) Split bone needles	x	x?	x?	?
j) Engraved shell ornaments	x	x	x?	x?
k) Cannel coal ornament	x	x?	x	?
l) Galena coal ornament	x	?	x?	?
m) Astragalus artifact	x	x?	x	x
TOTALS	13	11-2?	13	8-5?

*X means trait present; x? means trait probably present; ? means trait unknown; 0 means trait absent.

TABLE IV

MIDDLE MISSISSIPPI TRAITS FOUND ON EAST SIDE OF MISSISSIPPI VALLEY AND NOT ON WEST SIDE

1. Oval ceremonial house.
2. Rectangular fire bed.
3. Polished black floors.
4. Small fireplaces at corner of house.
5. Circular dwelling houses.
6. Banquettes—undetermined.
7. Stone work on floors.
8. Metates overlying ceremonial fireplaces.
9. Stone daggers.
10. Stone spheres.
11. Barbed antler points.
12. Hour glass-shaped beads.
13. Stone cist burials (found on west side, north of Cape Girardeau).

VIII. CHRONOLOGICAL SEQUENCE

While the question of exact chronology must await future data, perhaps a few words may be said about the relative position of the time of occupation of the site. Three lines of evidence indicate that the site was no longer occupied by the early part of the Eighteenth Century.

In the first place, investigation of the site has so far revealed only one cultural component, although evidences of several periods of occupancy were found. Secondly, the site is entirely pre-historic, as no traces of any articles of white man's manufacture, such as metals or glass beads, were excavated. Thirdly, the stump of the large sassafras tree which died about 30 years ago indicates a growth of about 200 years.

The question of possible occupancy by a tribe during a period from DeSoto's discovery of the Mississippi River in 1541 to Marquette's voyage down the River in 1673, or from the latter date to 1700 is worth considering.

Maps of the Mississippi Valley constructed during the period from 1703 to 1765 show a good sized stream entering the river at about the location of the New Madrid bend. On such maps this stream bears the name of the Chepoussa (with various spellings), or Sound River. In Hodge's *Handbook of American Indians* (12) we find that "Chepoussa was a name applied by LaSalle to a band of Illinois . . . . probably connected with the Michigamea." The Chepoussa was the southern-most member of the Illinois confederacy and was found by Marquette in

a village near a lake bearing their name, which was later identified as Big Lake in Northeastern Arkansas. The Michigamea had been driven south from their homes along the Illinois River by the Sauk and Foxes. Other villages occupied by them on the western side of the Mississippi south of St. Louis are shown on old maps of the period. About the end of the Seventeenth Century they were driven out of Southeast Missouri by the Quapaw or the Chickasaw and returned to Illinois to unite with the Kaskaskia Tribe.

The possible identification of the Chepoussa River with Little River, on which the Matthews Site is located, is based on evidence obtained from studying the maps of the region previous and subsequent to the great New Madrid Earthquake of 1811. Previous to 1811 a river, thought to be either Little River or St. John's Bayou, is shown emptying directly into the Mississippi near New Madrid. In the first map published in 1812, after the earthquake, Little River is shown as a part of the St. Francis River system, a clear case of stream piracy, probably caused by the depression of the natural low divides between the two rivers (6). The Michigamea were an Algonkian-speaking people who came down from the north. Their totemic animal was the crane, but the exact identification of their material culture has not yet been made by an archaeologist. However, the possibilities of their having at one time occupied the Sikeston Ridge cannot be overlooked.

The possibility of an earlier occupation by the Siouan-speaking Quapaw rests on still less secure foundations. The Quapaw are supposed to be one of the tribes encountered by DeSoto in 1541 after he crossed the great river in the vicinity of the Arkansas River. In 1673 the Quapaw were identified by Marquette with the Akansea who gave their name to the river. The Akansea are recorded as being builders of mounds, earthworks, and fortifications. Their village houses were long with domed roofs and contained several families. "The Akansea were active tillers of the soil, and also manufacturers of pottery, many of the finest specimens taken from the mounds in E. Arkansas in all probability having been made by this tribe."[13] The resemblance of this elaboate fine ware of Northeast Arkansas to that of Southeast Missouri has already been pointed out. We learn further that the Quapaw were related to the other Siouan tribes of the Missouri Valley, and that their traditions speak of their having come from the east, splitting into two divisions at the junction of the Mississippi and Ohio Rivers. The Omaha were the people who went upstream and the Quapaw were those who went downstream. It is probable that in their southern journey

they passed through New Madrid County and may have had some part in the building of the ancient settlements of that section. Here again, as with the Michigamea, our meagre knowledge of the archeology of the Quapaw prohibits us from saying with certainty that they were the builders of the Matthews Village and earthworks. However, the lack of any sign of white man's influence at this site makes us think an occupation by any historic tribe was unlikely.

IX. SUMMARY AND CONCLUSIONS

Summing up all the evidence gathered by the excavations at the Matthews site, we seem to have the picture of a people primarily sedentary and agricultural in nature, but with hunting and fishing interests, settled on an important water course that allowed access to the Mississippi River. That they had developed a rather complex state of primitive society, possibly with a caste system and elaborate ideas of religion, we infer from the nature and diversity of the mounds, the methods of burial, and the enclosing of large number of house sites within a protecting embankment or palisade. The lack of manufactured articles have led the writers to conclude that this village was the home of an unidentified tribe of the prehistoric or possibly protohistoric period. Culturally it belongs to the Middle Mississippi Phase. The present tendency is to subdivide the Middle Mississippi into early and late stages. The New Madrid Focus belongs to a late stage of the Middle Mississippi. The village occupation probably dates somewhere between 400 and 800 years ago. However, the question of the exact chronology must await the determination of the cutting date of the house posts and timbers found in the burned dwellings. Specimens of charred posts from different parts of the site were carefully saved and treated with a solution of paraffin in gasoline to permit transportation to the Dendrochronological Laboratory of the University of Chicago.

In view of the present data the writers incline to the theory that these people were of southern origin, possibly intruders into a hostile country. But beyond this it is difficult to determine just who these people were and what finally became of them.

X. REFERENCES

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[4]W. B. Potter and E. Evers, "Archaeological Remains in Southeast Missouri," Academy of Science of St. Louis, *Memoir,* No. 1, 30 pp., Salem, Mass., 1880.

[5]G. C. Swallow, "Report of Excavations in New Madrid County," Peabody Museum, *8th Annual Report,* pp. 16-28, Cambridge, Mass., 1875.

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[7]W. J. McGee, "A Fossil Earthquake," *Bull. Geo. Soc. Am.,* Vol. 4, pp. 411-412, 1892.

[8]J B. Berry, J. E. Wrench, and C. Chapman, "The Archaeology of Wayne County," *The Missouri Archaeologist,* Vol. 6, No. 1, June, 1940.

[9]Data for Kincaid Site from notes in possession of the Department of Anthropology, University of Chicago.

[10]Data for the Wickliffe Site from notes in the possession of R. M. Adams.

[11]Clarence B. Moore, "Some Aboriginal Sites on the Mississippi River," *Academy of Natural Sciences of Philadelphia,* Vol. XIV, p. 447, 1911.

[12]F. W. Hodge, "Handbook of the American Indian," Bureau of American Ethnology, *Bulletin* 30, Vol. I, p. 244.

[13]F. W. Hodge, "Handbook of the American Indian," Bureau of American Ethnology, *Bulletin* 30, Vol. II, p. 335.

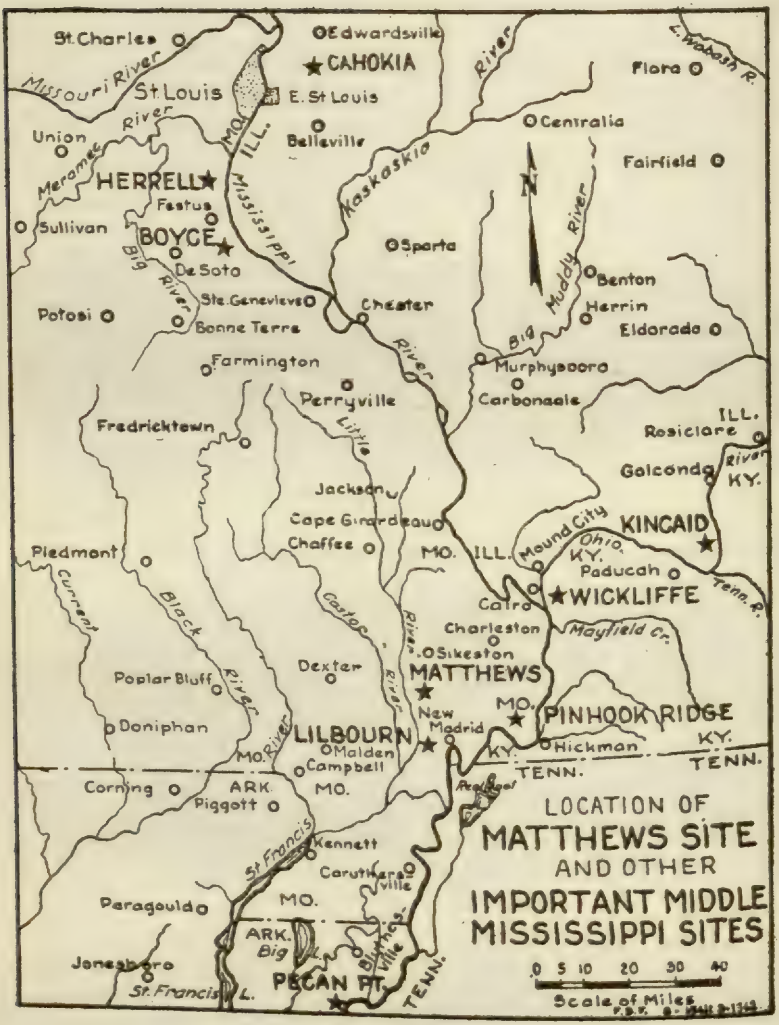
St. Charles
Edwardsville
CAHOKIA
Missouri River
St. Louis
E. St Louis
Mississippi River
Illinois River
Wabash R.
Flora
Union
Belleville
Centralia
Meramec River
HERRELL
Kaskaskia River
Fairfield
Festus
Sullivan
BOYCE
Sparta
N
Big River
De Soto
Muddy River
Benton
Ste. Genevieve
Chester
Herrin
Potosi
Bonne Terre
Eldorado
Big Muddy River
Farmington
Murphysboro
Perryville
Carbondale
Fredricktown
Little River
ILL.
Rosiclare
Golconda
Ohio River
KY.
Jackson
Cape Girardeau
KINCAID
Piedmont
Chaffee
MO.
ILL.
Mound City
Paducah
Current River
Black River
Cairo
WICKLIFFE
Tenn. R.
Charleston
Mayfield Cr.
Castor River
Sikeston
Dexter
MATTHEWS
Poplar Bluff
New Madrid
PINHOOK RIDGE
Hickman
Doniphan
LILBOURN
Malden
Campbell
KY.
TENN.
Corning
ARK.
Piggott
MO.
Reelfoot
LOCATION OF
MATTHEWS SITE
AND OTHER
IMPORTANT MIDDLE
MISSISSIPPI SITES
Kennett
St. Francis River
Caruthersville
Paragould
MO.
ARK.
Big Lake
Blytheville
Jonesboro
St. Francis L.
PECAN PT.
TENN.
0 5 10 20 30 40
Scale of Miles

PLATE I

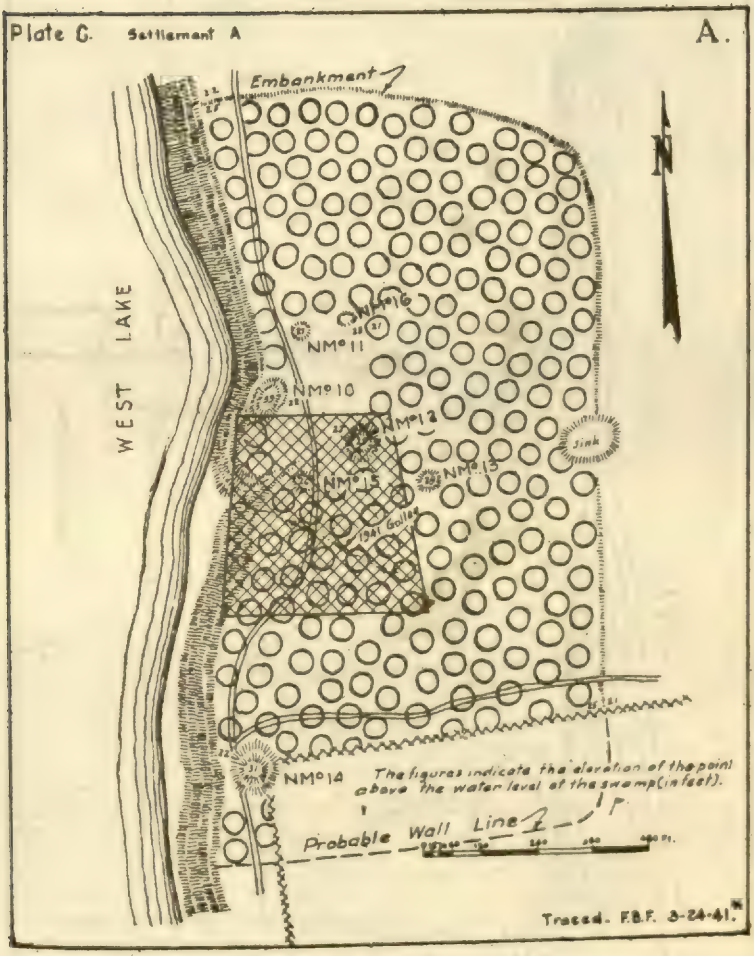

PLATE II
Village Site NmV3

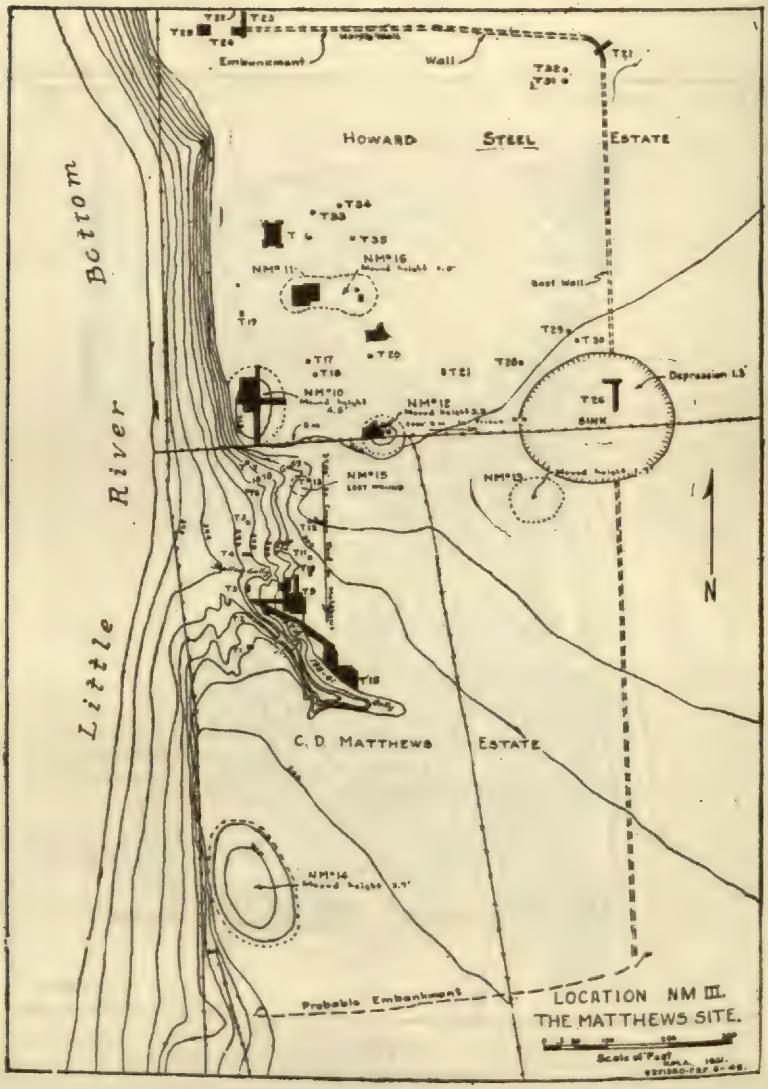

PLATE III
Location NM III The Matthews Site

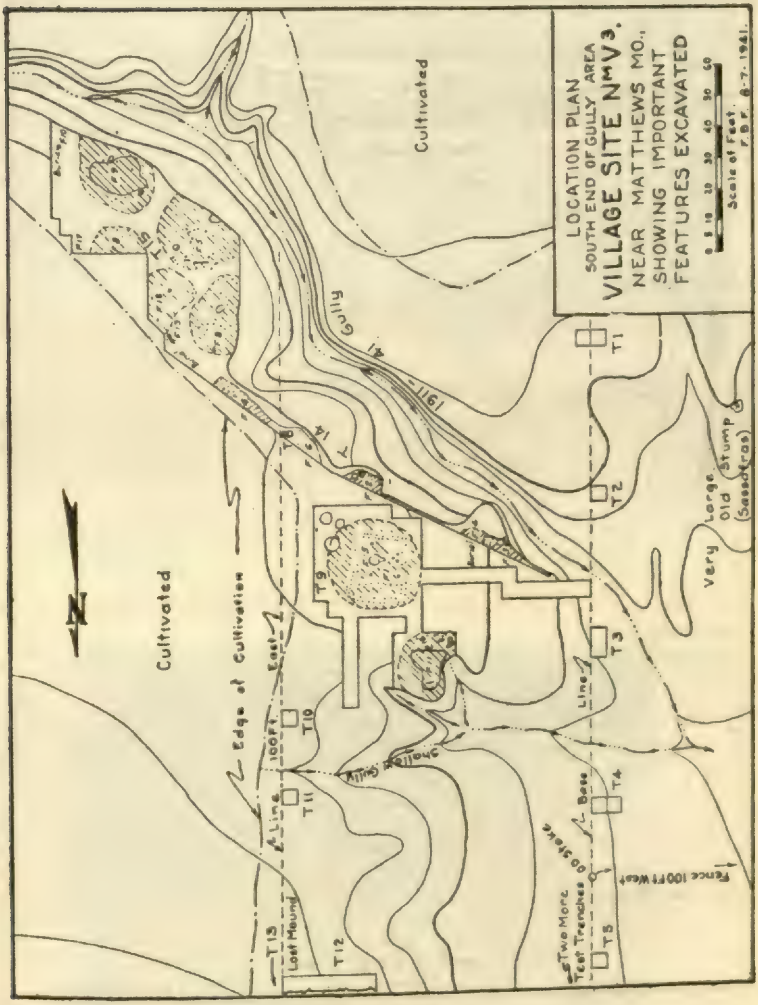
LOCATION PLAN
SOUTH END OF GULLY AREA
VILLAGE SITE NMV3.
NEAR MATTHEWS MO.,
SHOWING IMPORTANT
FEATURES EXCAVATED
Scale of Feet
F.B.F. 8-7-1941.
Cultivated
Cultivated
Gully
1911
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
Lost Mound
Edge of Cultivation
East
100 Ft.
A Line
B Line
Willow
Very Large Old Stump (Sassafras)
Two More Test Trenches
Fence 100 Ft West
Bass

PLATE IV

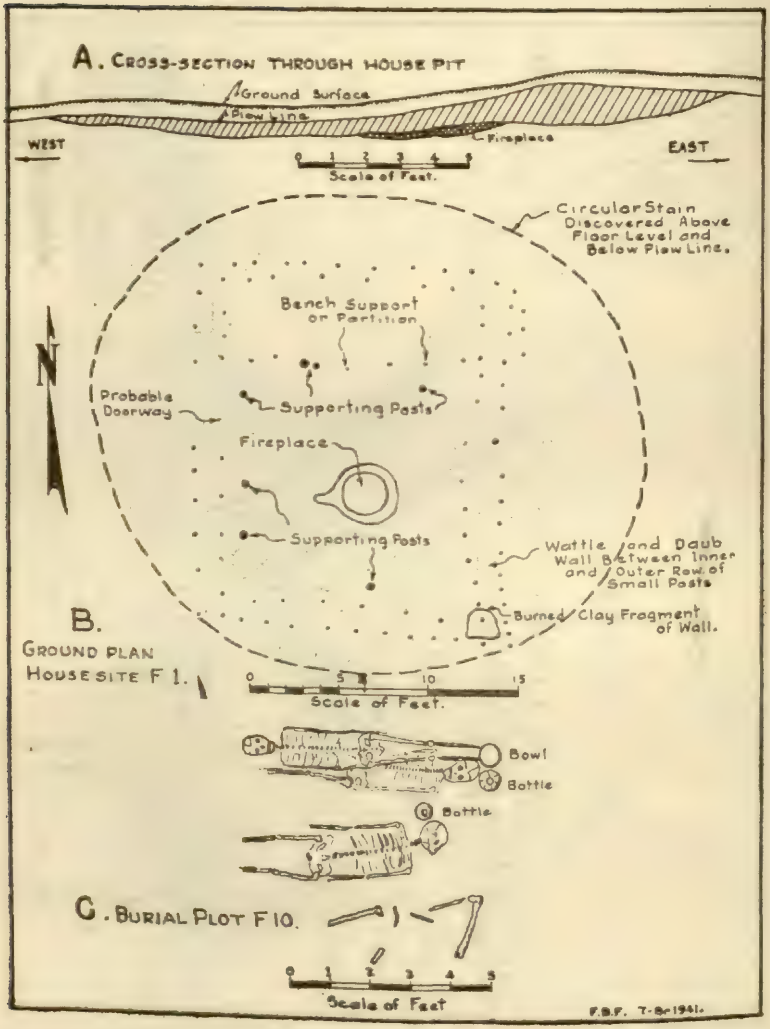

PLATE V

A. Cross-Section Through House Pit
B. Ground Plan of House Site T9, Fl
C. Burial Plot F10

PLATE VI A
Circular Appearance of House Site Below Plow Line

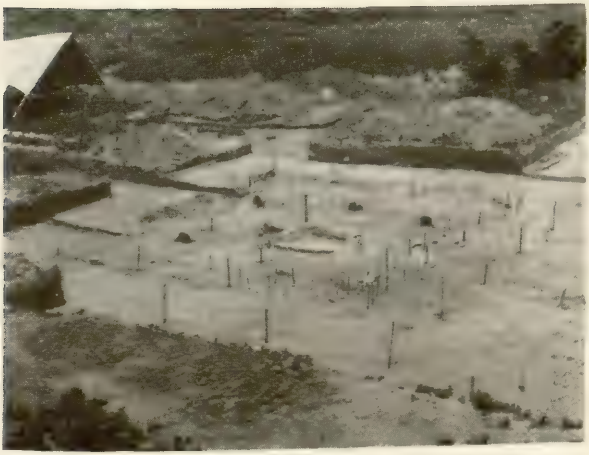

PLATE VI B
Rectangular Floor Plan with Construction Features

PLATE VII
South Half Traverse Trench
Showing Internal Structure of Ceremonial Mound

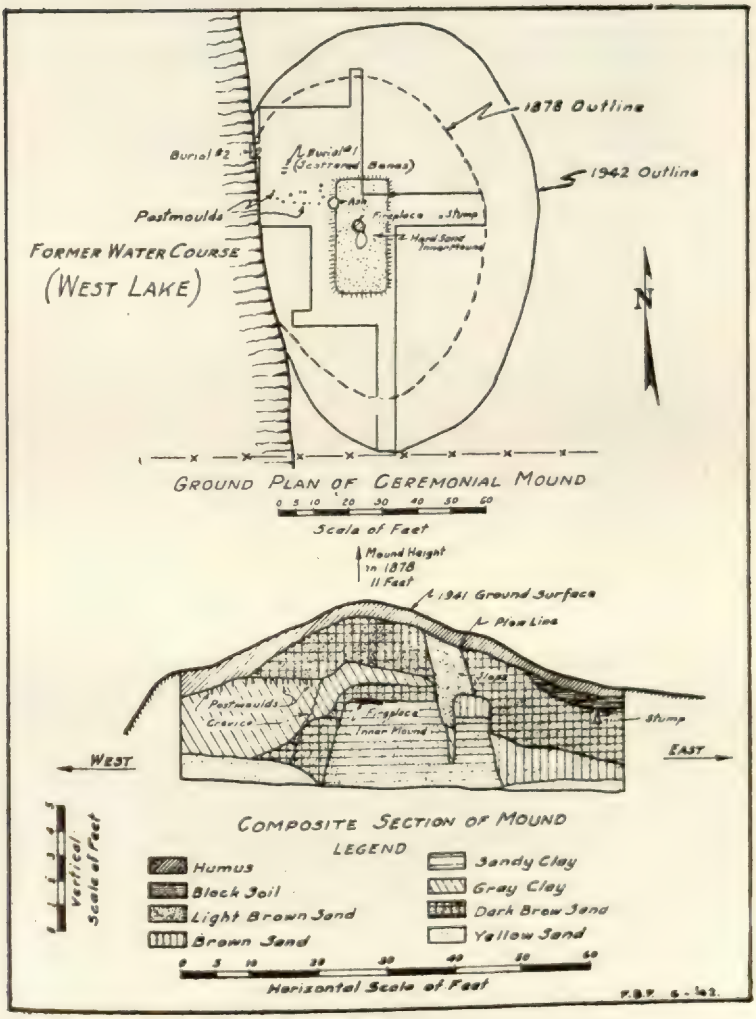

PLATE VIII

Ground Plan and Composite Section of Ceremonial Mound NM°10

PLATE IX A
Exposed Palisade with Sticks Indicating Postmolds

PLATE IX B
Three Overlapping House Impressions in NM°11

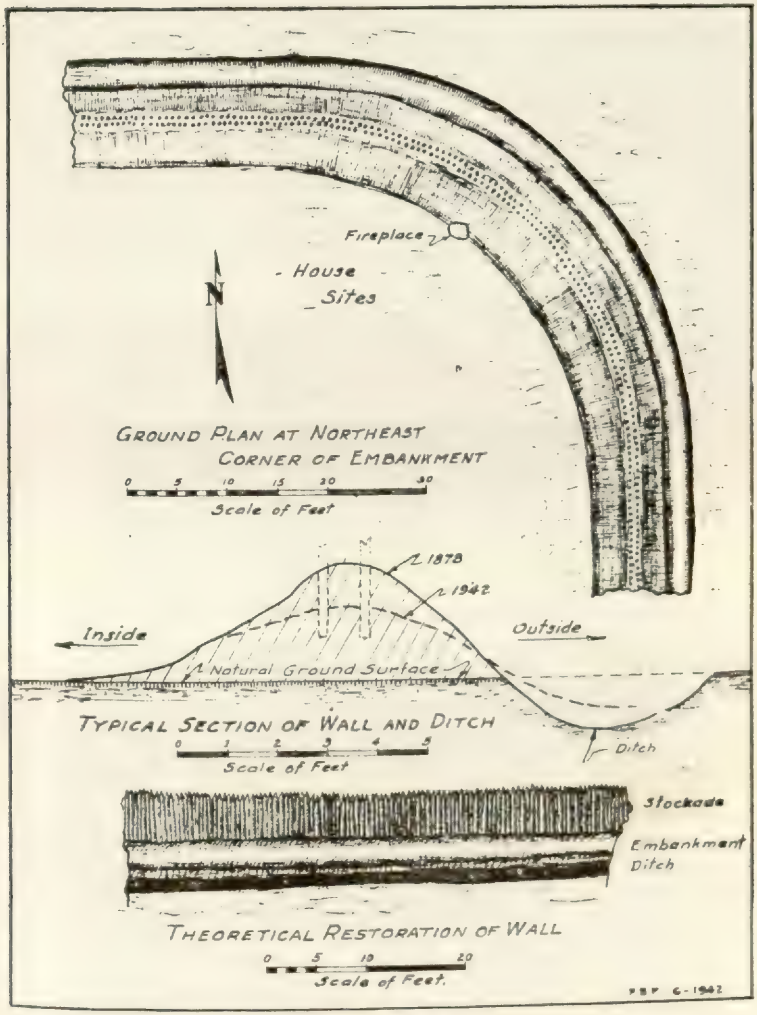

PLATE X

Ground Plan, Section, and Theoretical Restoration of Wall and Ditch

PLATE XI A — Burial Near House Sites F8 and F12

PLATE XI B — Burial Plot F10 with Funeral Pottery

PLATE XII A
Burials Near House T16, F1

PLATE XII B
Occipital Deformation of Skulls

PLATE XIII A
Small Artifacts of Bone, Flint, and Shell

PLATE XIII B
Large Artifacts of Chipped and Ground Stone

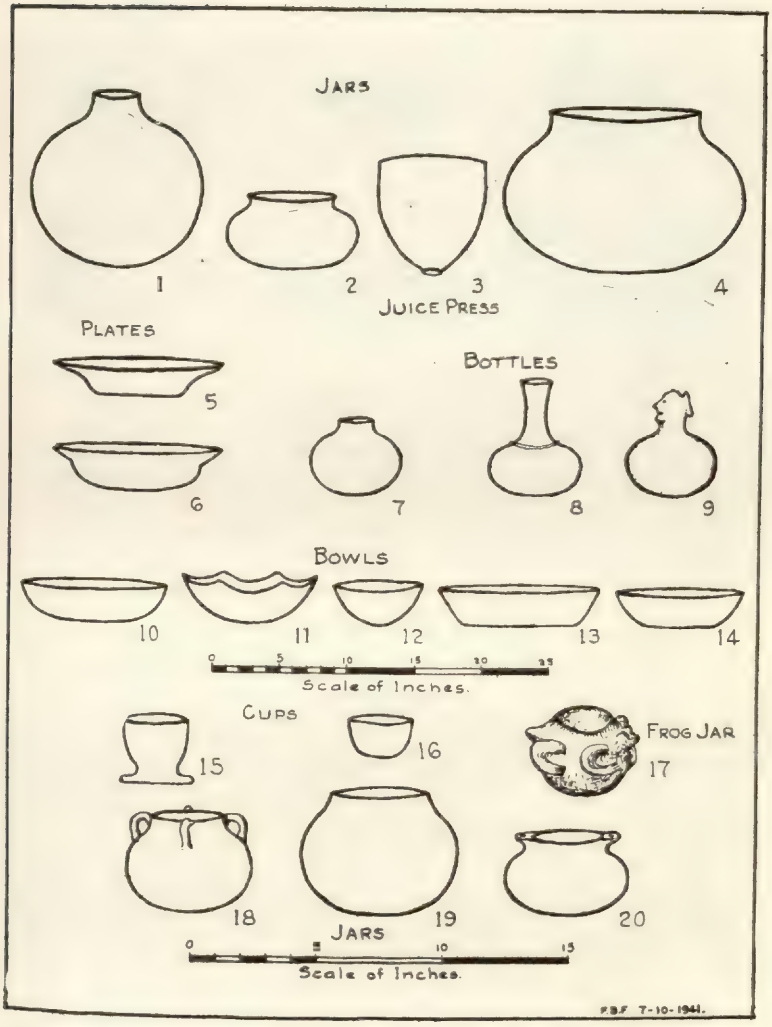

PLATE XIV
Pottery Shapes

PLATE XV A
Incised Decorations on Jars

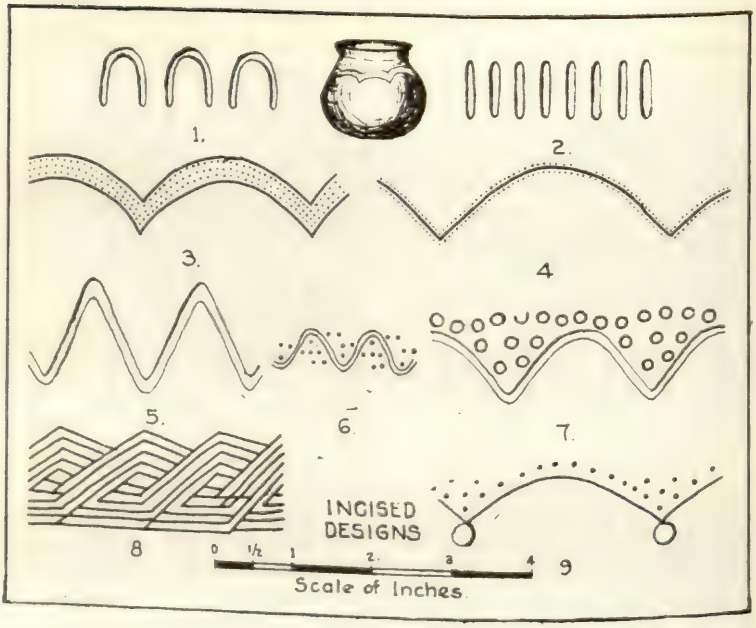

PLATE XV B
Incised Decorations on Jars

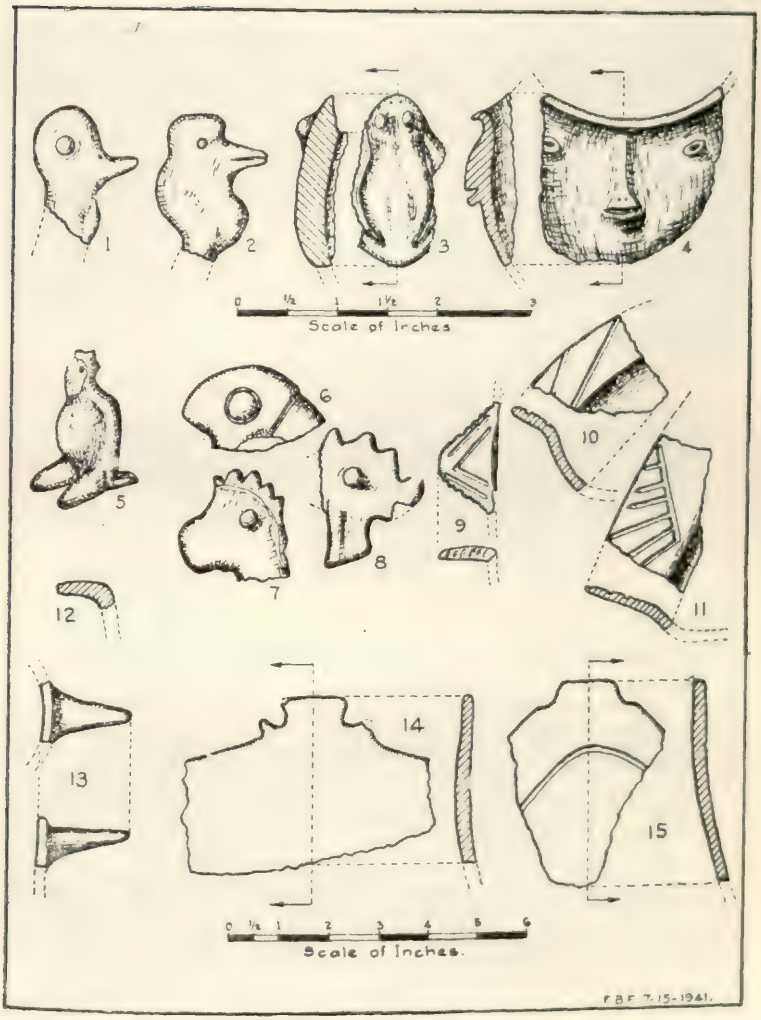

PLATE XVI
Animal Effigies and Trailed Designs on Plates

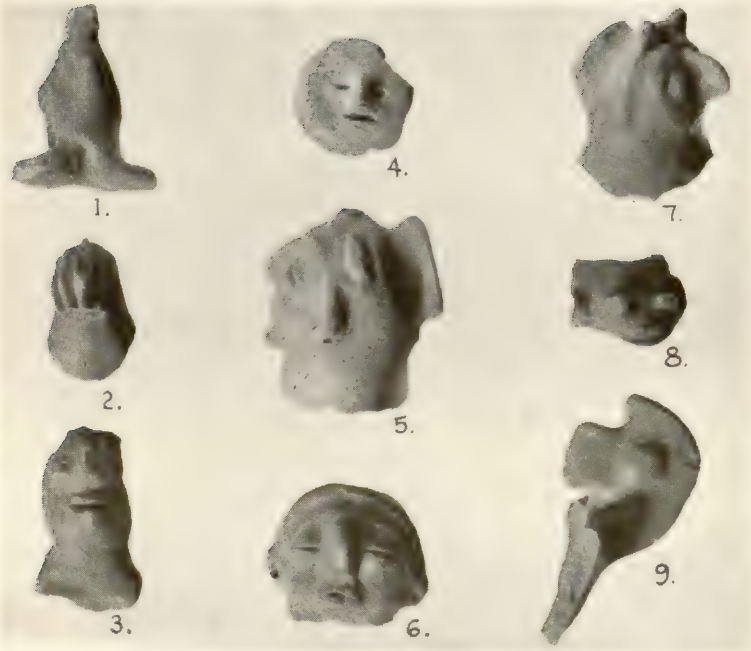

PLATE XVII

EFFIGY WARE FEATURES — 1. Seated Figure, 2. Animal Head, 3. Human Head, 4. Human Face, 5. Human Head, 6. Human Head, 7. Owl Head, 8. Frog Head, 9. Bird Head.

PLATE XVIII A
Restored Burial Pottery

PLATE XVIII B
Restored Village Pottery

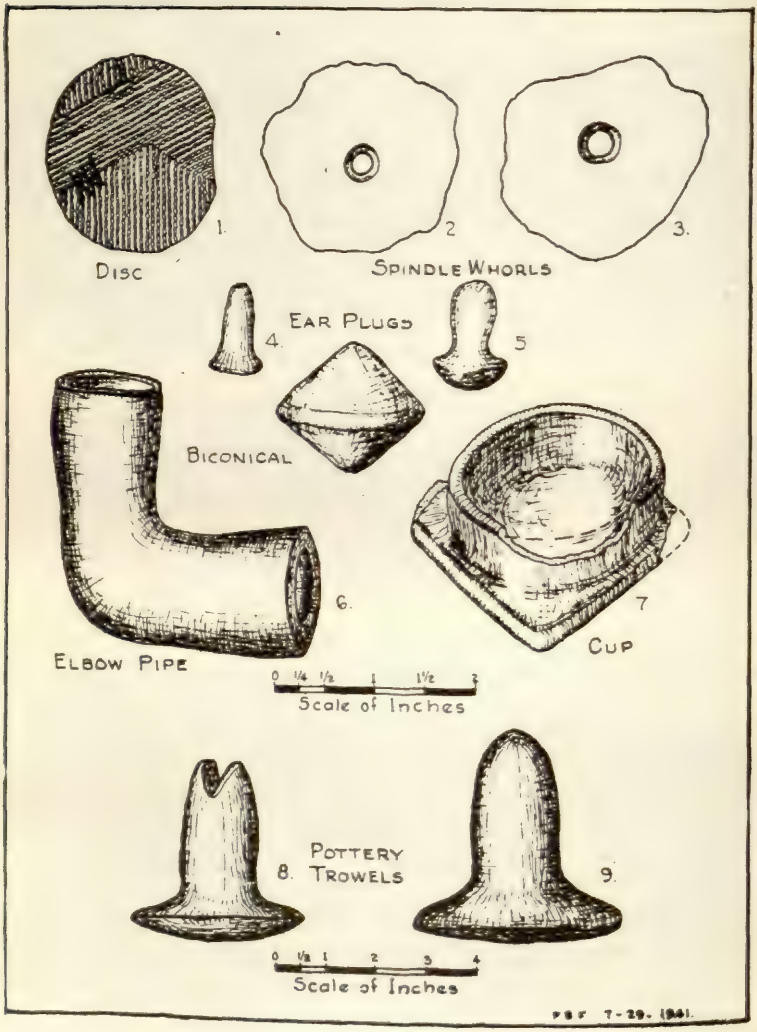

PLATE XIX
Miscellaneous Pottery Objects

The Academy Library

The Library of the Academy of Science of St. Louis originated soon after the founding of the Academy in 1856. By the turn of the century it was said to be the most extensive of its kind west of the Allegheny Mountains. The Library consists of approximately 70,000 volumes and pamphlets. Preserved here are the journals and reports of scientific organizations, learned societies and universities from all parts of the world covering a period of many years. Here are the original contributions of scientific workers in many fields. One may find here the significant literature of the early years of development in many fields.

The Library is thus invaluable to investigatory who desire to go into the early work on their subject. It should be stressed, however, that, not only are the older publications found here, but the latest scientific literature is being received daily. The fact that some of the material housed here is very rare and not available elsewhere in the west emphasizes the importance of this Library. Publications in all branches of both pure and applied sciences are represented. Its value to commercial and industrial concerns of the community is evident.

Some indication of the activity of the Library is shown by noting the rate new material was being received before the war. In 1940 the Library received 2153 publications from institutions on the exchange list. Many of these were continuations of sets dating back many years. On the exchange list are 338 foreign institutions and 138 from the United States.

The Library is housed in the Cupples I Building on the campus of Washington University. It is available not only to members of the Academy but to all requiring its use.

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NUCLEAR ENERGY and the HYDROGEN BOMB

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OF SAINT LOUIS

VOLUME XXXI

NUMBER 5

NUCLEAR ENERGY

AND THE

HYDROGEN BOMB

●

ARTHUR L. HUGHES

Professor of Physics

WASHINGTON UNIVERSITY

Saint Louis

Transactions of the

ACADEMY OF SCIENCE

of

Saint Louis

4642 Lindell Blvd. St. Louis 8, Mo.

VOLUME XXXI NUMBER 5

Issued April 30, 1950

Price 50c

ACADEMY OF SCIENCE OF ST. LOUIS

The Academy of Science of St. Louis was founded in 1856 and chartered by the Nineteenth General Assembly of the State of Missouri by an act dated January 17, 1857. The objects for which the Academy of Science was founded are set forth in the Charter. They are threefold: first, the advancement of science; second, the establishment in the City of St. Louis of a museum for the illustration and study of the various branches of science; third, the creation of a scientific library. Membership in the Academy is not limited to those actively engaged as scientific workers; those interested in science are equally welcome.

THE MUSEUM

An early and important museum of the Academy of Science was totally destroyed by fire in 1869. This appears to have been one of the significant museums of the country at the time, containing many type specimens. It would no doubt have been the nucleus for a great institution in the city of St. Louis. Later attempts to found a museum were not very successful until the present museum, 4642 Lindell Blvd., was established in 1943. There is a growing appreciation by the community of the scientific and educational work of the present museum. It is, however, only the beginning of the extensive science center planned for the future.

The Academy Library

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NUCLEAR ENERGY AND THE HYDROGEN BOMB[1]

(Arthur L. Hughes, Professor of Physics, Washington University)

A satisfactory understanding of how nuclear energy is released in the uranium bomb and how it may possibly be released in the hydrogen bomb calls for a survey of many apparently unrelated developments in science during the last half century. Our success in releasing nuclear energy at will, is, to my mind, perhaps the most outstanding illustration of how new and important discoveries are made by not going after them. They are often made as a result of scientists following their individual curiosity as to this or that phenomenon without the slightest idea of what will be the end result.

I shall first briefly enumerate the various significant dates in the history of the background to the atomic bomb.

In 1897 Madame Curie isolated radium and it was found later to have properties of a very peculiar kind. Unlike all other elements which seemed to be eternal and everlasting, radium transmutes itself at a definite rate into a different element, radon. The study of this and related phenomena opened up the fascinating field of radioactivity, or natural transmutation. The leader in this field was Rutherford.

In 1906 Einstein published his theory of relativity. As a side product of this theory was the startling prediction that if matter could really be made to disappear, a definite amount of energy would always appear in its place and vice-versa. To be specific, if one ounce of matter of any kind could be made to disappear entirely, then 700,000,000 kwh of energy would appear in its place. This is nearly as much as the power plant at Keokuk puts out in a year. Alternatively, it is roughly equal to the total power output of the Union Electric Company for two months.

Einstein's prediction remained unverified until the 1930's when it was shown in certain experiments in which a minute fraction of the mass involved disappeared, that the right amount of energy appeared in its place.

In 1920, Rutherford carried through the first successful experiment in artificial transmutation. By bombarding nitrogen atoms with alpha particles from radium, he succeeded in creating oxygen atoms.

In the late 1920's E.O. Lawrence and others devised particle accelerators, such as the cyclotron, to accelerate suitable particles, such as protons and alpha particles, to repeat and extend Rutherford's transmutation experiments. The advantage of the particle accelerator was that it could provide ever so many more bombarding particles than were available to Rutherford who used radium as a source of alpha particles.

[1] An address at the Annual Dinner of the Academy of Science of St. Louis March 1, 1950.

In 1932, Chadwick discovered the neutron, a particle which has practically the same mass as the proton which is the nucleus of the hydrogen atom, but differs from it in that it has no electrical charge whereas the proton has a positive charge.

In 1939,three German scientists discovered that when uranium is bombarded by neutrons it undergoes fission into two nuclei with a tremendous evolution of energy. So far there was no glimmer of any idea as to how to control this release of energy. In 1940, there came the first indication of how a controlled chain reaction to utilize nuclear fission could perhaps be devised.

On December 2, 1942, in a small building under the bleachers of the Stagg Field at the University of Chicago, a group of men headed by A.H. Compton and E. Fermi, carried through the first successful experiment in which nuclear energy was released at will and under perfect control.

On July 16, 1945, at Alamogardo, New Mexico, the first atomic bomb was tested successfully. This was an explosive release of nuclear energy, uncontrolled in the sense that once started, it went through to its natural termination.

So much for a rapid survey of the principal streams of activity in physics which led to the first feeble steps in man's mastery of the release of energy from the nucleus of the atom.

Some of the points touched on need to be elaborated to give a better understanding of the principles involved in utilizing nuclear energy.

Early in this century the physicists' picture of the atom had become fairly well stabilized. The atom consists of a heavy nucleus with a positive charge at the center surrounded by a cloud of electrons, each with a negative charge, in rapid choatic motion around the nucleus. For example the atom of gold consists of a heavy nucleus carrying 79 positive charges surrounded by a cloud of 79 electrons in rapid motion. Each electron carries a single negative charge. The average distance between the electrons and between the electrons and the nucleus is roughly 100,000 times the diameter of each. You then see that the atom is largely empty space. If you could blow up an atom of gold to the size of this room the nucleus would be represented by a large hornet motionless at the center of the room with 79 flies buzzing around in all direction within the room. In spite of the emptiness of the atom, the electrons form an effective barrier shielding the nucleus. Even in the case of the hydrogen atom where there is but one electron, its rapid motion in all directions around and about the nucleus provides effective interference for the nucleus. The idea I want to put across is that the nucleus is well protected in atoms by the electrons. Only a very high energy particle can crash through the interference.

Chemistry is the study of the way atoms combine with each other to form molecules. Chemical combinations are bewildering in their number and variety, but in the last analysis they are all describable as the tangling together of the superficial electrons in each atom involved. The inner electrons are wholly unconcerned and the same is true of the nuclei. Now it is easy to measure the energy evolved when a compound is formed out of its elements and then to compute the energy evolved per

atom taking part. This is quite important as I want to contrast it with the energy evolved per atom in radioactivity. In the 1900's it was recognized that the energy evolved per atom in the transmutation of radium into radon, or indeed any radioactive element into another, was a million or more times greater than in any chemical process. Radioactivity was a very rare thing. Chemical processes are very common. In 99.999 per cent of all that we see going on around us, combustion, corrosion, animal and vegetable metabolism and so forth, a chemical process is involved, and this is described in terms of the tangling or untangling of two or three superficial or outer electrons in the atoms involved. As I have already indicated, the energy evolved per atom taking part is found to be about a million times smaller than the energy evolved per atom in radioactivity. This, among other things, led physicists to the conclusion that radioactivity must be a property of the nucleus of the atom whereas chemistry is a property of the outer electrons of the atom.

In the particular chemical process known as combustion, you can control the evolution of heat at will. If you want more heat, you feed in more air to the furnace and if you want less, you diminish the air supply. But there appeared to be no way whatever of controlling the evolution of energy in radioactivity; it went on at its own pace and nothing that man could do would speed it up or slow it down. It used to be said, and is still true, that there is enough energy in a few ounces of radium to drive a large liner across the Atlantic Ocean, but the catch is that it would take 2000 years for the trip. So here was the tantalizing situation. We knew that there was a colossal amount of energy tied up in the nucleus of a radioactive atom and presumably in the nucleus of any atom, a million times greater than is obtainable when the atom enters into chemical combination. Yet whereas we had control of the evolution of chemical energy, we had no inkling of how to extract the much greater energy, from the nucleus when we needed it, and turn it off when we did not need it. We had to wait until December 2, 1942 for a method of controlling the release of nuclear energy at will and actually this was effected only for one particular element, uranium, which had just exactly the right combination of properties to make it possible.

The study of radioactivity up to 1920 was rather like that of astronomy. In a sense both are observational sciences for just as you can't go up in the sky and push the stars around to see how they will react under different conditions, so you could do nothing to transmute one nucleus into another at will. In 1920, however, Rutherford succeeded in artificially transmuting nitrogen atoms into oxygen atoms by bombarding them with high energy alpha particles from radium. This was an epoch making discovery.

I have said that, in all ordinary processes that atoms undergo, the electron cloud shields their nuclei most effectively and so they remain untouched. However, the alpha particles from radium are exceedingly small but have tremendous energy--roughly 5 million volts. This enables them to crash through the electron cloud without much hindrance. However, not every alpha particle hits a nucleus. Indeed only one in

several million does so. You can't aim an alpha particle at the nucleus of an atom. All you can do is to shower atoms with a huge number of particles in the hope that occasionally one will make a square hit on a nucleus deep down in an atom. It is like shooting with a battery of shotguns in the general direction of a black owl flying high up at midnight on a moonless night in the hope that one shot might by chance hit it.

The accelerators, like the cyclotron, which came on the scene around 1930 were a great help in that they provided far more high speed particles than one could get from all the radium in the world. As a result, information came in more rapidly.

Soon after 1932 our present picture of the nucleus of the atom came into being. A nucleus is composed of protons and neutrons packed tightly together. The proton carries a positive charge; the neutron carries no charge at all. The proton and neutron have very nearly the same mass. All nuclei are made up of protons and neutrons. The helium nucleus, for example, is made up of two protons and two neutrons, giving a mass of four units. There are two varieties of Li nuclei, one contains 3 protons and 3 neutrons and so has a mass of 6 units, the other contains 3 protons and 4 neutrons and so has a mass of 7 units. These are called isotopes of Li, Li-6 and Li-7. Chemically they are identical and so they cannot be separated by any chemical process.

A great deal of research has been done on determining the exact masses of the isotopes. When I speak of Li-6, I mean the isotope whose mass is very close to 6 units; actually it is 6.01682. The same can be said of all other isotopes. Their masses are close to whole numbers and the true number is known to a very high degree of accuracy for most isotopes.

An interesting discovery was made when the isotope Li-7 was bombarded by protons of energy a little below 1 Mev. An "ev"(electron volt) is a convenient unit in chemistry; a "Mev" (million electron volts) is more suitable for nuclear work. The result was the appearance of two He nuclei flying apart with an energy of 17 Mev. Thus we are getting much more energy out than we put in. This looks like getting something for nothing. Actually it is not so. If we take the exact masses of the isotopes before, i.e., of the Li-7 and the proton which hit it, and the exact masses of the resulting helium nuclei, we find that they don't balance. There is a slight loss of mass. The excess energy appearing afterwards was found to be exactly what it should be in terms of the mass lost, according to Einstein's 1906 formula. Experiment after experiment confirmed the Einstein formula spectacularly. One might jump to the conclusion that here we were tapping the energy in the nucleus. This is indeed true, but it is not a profitable tapping. Remember that to make one square hit on a nucleus, you have to waste a million or more high energy particles. For the rare individual event in which the accelerated particle hits the nucleus, it is true you are getting more than you put in. In the overall picture you are getting far less than you put in, because so many particles are wasted uselessly.

Rutherford, perhaps the greatest experimental physicist of recent times, the outstanding leader in radioactivity and the discoverer of artificial transmutation said shortly before he died in 1937 that he saw no

hope of ever tapping the sources of energy within the nucleus. Only two years later came the crucial discovery which made it seem possible, and in Chicago in 1942, it was actually carried through successfully.

In 1939 three German scientists discovered a new effect, the fission of uranium as a result of bombardment by neutrons. Up to this time, all transmutation experiments in which various nuclei were bombarded by high energy particles of one kind or another, the transmutation was to a new nucleus differing only by one, two or three particles from the target nucleus. That is to say, the product nucleus would differ by one or two protons or one or two neutrons from the original nucleus. It has sometimes been referred to as merely a chipping process. The new thing about the 1939 experiments on the bombardment of uranium nucleus containing a mixture of 235 protons and neutrons was that the uranium nucleus was split into two unequal parts containing say 100 particles and 135 particles approximately or indeed almost any two numbers which add up to about 235. The resulting nuclei can be reconnized as pairs of well known elements, for example, krypton and barium. The resulting nuclei fly apart with a huge amount of energy, 180 Mev, which, as they crash through adjacent matter, heat it up by friction.

Where does this energy come from? If you look at a list of the exact masses of the product nuclei, for example, krypton and barium, and of the uranium nuclei you start with, you find that the combined masses of the products fall slightly short of the original mass before fission. It is indeed true that the mass which disappears is only 0.1 per cent of the original mass, but this accounts for the huge energy release, exactly as Einstein's formula predicts. This energy release per atom of uranium undergoing fission (even though only 0.1 per cent of the mass is lost) is still roughly 40,000,000 times greater than the energy release per molecule of CO_2 when coal is burned.

I want to emphasize that, at this stage, we still have no inkling of how to turn on or to turn off the supply of energy known to be in the uranium nucleus. So far, to make the uranium atom undergo fission, it has been necessary to supply millions of neutrons from an outside source in order that one or two of them may produce fission in a lucky collision. Scientifically 1939 and 1940 were exciting years; fission of uranium was studied with gusto. However, there was no more reason then than there was twenty years before to believe that useful amounts of nuclear energy could be released at will. Then came a discovery which changed the situation radically. It was discovered that every time a uranium atom undergoes fission it also emits several new neutrons. This opened up the possibility of a chain reaction and the possibility of a nuclear bomb or atomic bomb as it more often is called.

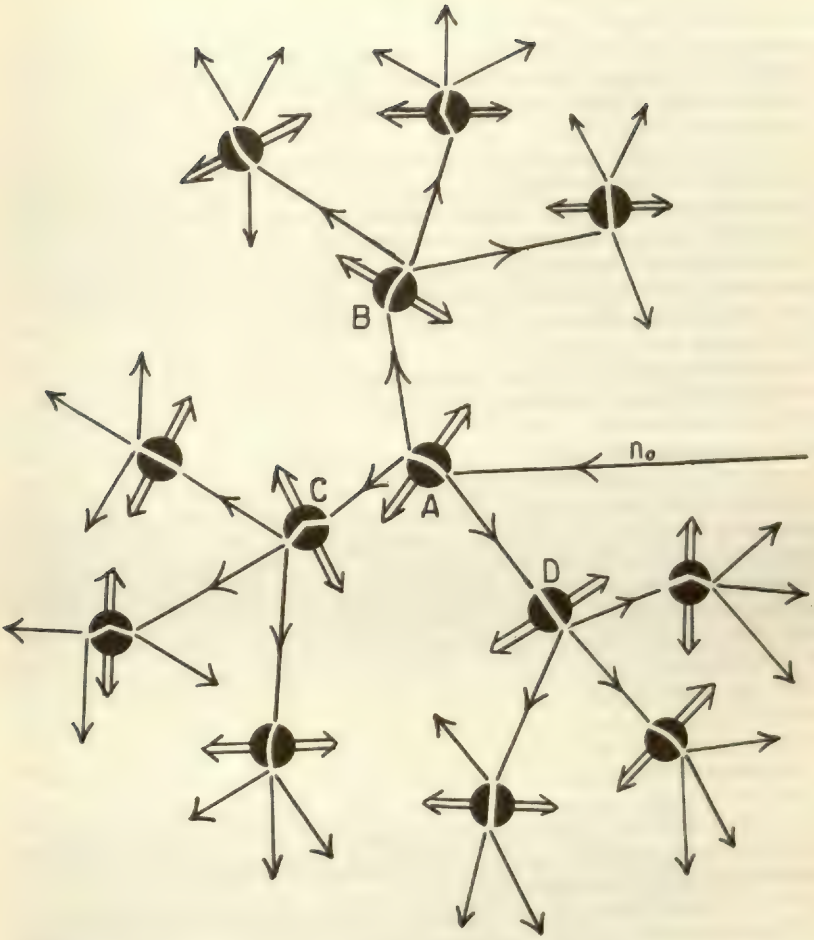
To me it is highly significant that, in 1940, when, for the first time, a glimmer of a possibility of using nuclear energy as a weapon appeared, scientists in this country, Canada and Britain quietly ceased to publish any further researches on uranium fission. This was a voluntary, self-imposed, censorship adopted long before the Army had any idea that a new and terrible weapon might possibly develop.

Now to return to the highly significant discovery of the emission of several neutrons whenever a fission process occurs. This makes possible a chain reaction. Suppose you had a piece of uranium the size of pea and you bombard it with neutrons from an outside source. Each of the neutrons which hits the nucleus of uranium atom causes fission, releases a tremendous amount of energy in the fission process and produces say three new neutrons. Now as the neutrons, on the average, travel a few inches in uranium before making a collission, it is clear that practically all will escape from the pea-sized piece of uranium. So when the external supply of neutrons is shut off, fission ceases in the uranium. But what happens when you have a piece of uranium say the size of this room? Suppose we introduce some neutrons somehow in the center of this large piece of uranium. Some of them will produce fission, releasing energy and each will produce say three new neutrons. Now because the chunk of uranium is so large, the neutrons will not escape. Suppose that each of these three new neutrons produces three fission events releasing energy and altogether nine new neutrons. These are still well inside and so we may suppose that they, in turn, will produce nine additional fission events with energy release and 27 additional neutrons. This business multiplies itself with tremendous speed and the energy release will blow the thing apart. In principle, a big piece of uranium could never exist because there are always a few stray neutrons which could initiate the multiplication effect. So we arrive at the notion of a critical mass below which the uranium is perfectly safe, but above which the uranium cannot exist without exploding.

I have spoken of the neutrons which are released at each fission event and which may be available for the chain reaction. There is a competition for these neutrons which can be used up in several ways.

1. escape to the outside.
2. capture by uranium nuclei leading to non-fission transmutations.
3. capture by impurities.
4. capture by uranium leading to fission.

Escape to the outside can be diminished by using a sufficiently large piece of uranium. Capture by impurites can be avoided by purifying the uranium as much as possible. There remains the capture of neutrons by uranium leading to non-fission changes. How can this be avoided? Some time ago I spoke about isotopes. Well, uranium has two isotopes, 238 and 235, which are present in natural uranium in the ratio of 140 to 1. Neutrons stopped by the U-238 do not lead to fission and so are wasted so far as sustaining the chain reaction. Neutrons stopped by the U-235 lead to fission and so to a self-sustained chain reaction. To make an atomic bomb we therefore need the U-235 as free as possible from U-238. To separate isotopes is a fantastically difficult problem. However by a tremendous effort it was done and adequate amounts of U-235 were ultimately obtained. The bomb then consists of two pieces of U-235 each of which is below the critical mass and so is non-explosive, but when put together add up to more than the critical mass and is explosive. So, the requirement is that the two pieces shall be kept apart, and when an explosion is needed, they shall be slammed together thereby producing the condition for the almost instantaneous chain reaction which results in the explosion.



A simplified picture of the chain reaction. A single neutron n_o, produces fission in nucleus A. The two fragments, recoiling with high energy are indicated by double arrows. The three new neutrons emitted at the same time are shown by single arrows. Each of these three neutrons produces fission in nuclei B,C, and D, and nine new neutrons. These in turn, produce nine fissions and Twenty-seven new neutrons. This multiplication process, the chain reaction, takes place with tremendous speed so that the evolution of energy is practically instantaneous.

Let me recall that in the uranium fission only 0.1 per cent of the mass of the uranium disappears when it is converted into its product nuclei. It would be optimistic to suppose that anything like this 0.1 per cent is fully utilized. We know by burning coal in a suitable calorimeter how much energy it is possible to get out of a pound of coal. Modern power plants deliver in the form of useful energy only about 30 per cent of the energy theoretically possible from the fuel. Engines made by James Watt two hundred years ago were far less efficient. It is likely that the first atomic bombs exploded may be regarded as in the James Watt stage of atomic energy and that, as new bombs are made, one must get an increasingly larger fraction of the energy theoretically available. This could be the interpretation of the guarded statement that the bombs exploded at Bikini were more effective than earlier bombs.

I have mentioned that the separation of the isotope U-235 from the isotope U-238 is a fantastically difficult job, far more difficult than any chemical separation. This led to the search for an element which might have the same fissionable properties as U-235 but which might be more easily separated by chemical processes from other elements. It was suspected that an element, now known as Plutonium, and which nobody had seen, could be manufactured, and might well have the same fission properties as U-235. Plutonium is made by bombarding U-238, the plentiful isotope of uranium with neutrons. The Washington University cyclotron played a large part in producing the first bit of Plutonium big enough to be seen. Large quantities of uranium were placed close to the cyclotron. The machine was set up to deliver neutrons, and these were delivered almost twenty four hours a day, week after week. At the end of the long bombardment, a chemical procedure was used to separate the accumulated Plutonium from the Uranium. Less than a pin head was obtained after all this work, the term "pinhead" is Smyth's, but it was enough for the chemists to verify that this "less than a pinhead of Plutonium" had the desired properties. The next step was to build the huge Plutonium plant at Hanford, Washington to produce Plutonium in the required amounts.

Only two isotopes, U-235 and Pu, have the qualities necessary to make an effective bomb. Energy is released in each of them by a fission process. The energy is released because the combined masses of the product nuclei are less than the mass of the parent nucleus, and the loss in mass, small as it is, only 0.1 per cent of the total mass, accounts exactly for the energy evolved, as Einstein's theory predicted long ago.

At this point, I want to emphasize again that the conversion of mass into energy in the case of U-235 or Pu is a very exceptional thing. There are roughly 800 isotopes among the nearly 100 elements. Only in the two cases of U-235 and Pu has it been possible to convert mass into energy by a chain reaction and this is because these two isotopes are unique in having the property of being fissionable by neutrons and possessing other properties all of which when properly used just make it possible to release nuclear energy.

Physicists have of course explored many other ways of releasing nuclear energy but without success. One approach which has been under much consideration is based on the fact that whereas a heavy nucleus gives out energy on breaking into two parts, i.e., when it undergoes fission, energy is liberated when two or more very light nuclei combine to form a slightly heavier nucleus. To be specific, we know that the helium nucleus is made up of two protons and two neutrons packed together and we know the exact value of its mass. We also know that the exact value of the mass of the helium nucleus is definitely smaller than the sum of the masses of the individual protons and neutrons before they came together. So, if we form a helium nucleus out of two protons and two neutrons, it is easily calculated that the loss of mass, and consequently the evolved energy, are about seven times greater than when a U-235 nucleus undergoes fission. The only thing left is to find a way of putting the helium nucleus together from its four component parts. This has not been done, and the outlook for doing it seems hopeless.

Professor Bethe of Cornell proposed in 1939 a theory for the origin of the sun's heat which is generally accepted. Deep down in the sun, the temperature is of the order of 20,000,000°C. This means that the atoms are moving about so rapidly that the electrons around the nuclei of different atoms now have some chance of colliding with each other. A collision between two nuclei provides an opportunity for a nuclear reaction. Two protons colliding may result in the creation of a deuteron and a positron. Energy is evolved. An alternative process which is more likely is a rather complicated set of six steps involving collision between protons and carbon and nitrogen nuclei in succession. In the overall accounting two protons and two neutrons disappear and a helium nucleus appears. The number of carbon atoms remains unchanged, they play the part of a catalyst. Since the mass of the product is less than the mass of the protons and neutrons one starts with, there is a loss of mass and therefore an evolution of energy. This theory gives results in excellent accord with the known facts about the sun's heat. The upshot of this is that we have very good reason for believing that the combination of very light nuclei into slightly heavier ones evolves energy. This then gives us confidence in the view that somehow the synthesis of say a helium nucleus from lighter nuclei on the earth would provide a great deal of energy. But what happens in the sun is no adequate guide to the reproduction of the process in a hydrogen bomb on the earth, for in the sun, time for the event to occur is unlimited, whereas in a hydrogen bomb it is essential that the whole process be over and done with in less than a millionth of a second so that the materials do not begin to fly apart long before the available energy is set free. What is the next step?

I suppose hundreds of physicists have doodled on paper with symbols representing light nuclei and tried to combine them in all sorts of ways to produce slightly heavier nuclei. Then by looking up tables of the exact masses of the nuclei concerned it is easy to calculate how much mass is lost in the process and so to estimate how much energy can be set free. Perhaps the most obvious way of making a helium

nucleus is to have two protons and two neutrons come together at exactly the same instant. Energy would be given out, but the chance of this occurring is so fantastically low that it is ruled out. The chance of two friends meeting each other at say the corner of Broadway and Olive, of course without previous planning, is extremely small, but the chance of four friends meeting at the same point at the same time without planning is astronimically smaller. Consequently we restrict ourselves to collision between two nuclei. In this business of doodling symbols on paper to see what possible combinations there are, one has plenty of nuclei to start with. For example we have the proton which is the nucleus of deuterium or heavy hydrogen, the triton which is the nucleus of tritium, or very heavy hydrogen, Li of mass 6, Li of mass 7, and Be of mass 9. The possible combinations of all these nuclei, two by two, are quite numerous and the possible yield of energy varies a great deal depending on the particular pair you are dealing with. However this is not the whole story by a long way. Some combinations go easily, others go with difficulty. So you have to know the probability of the type of combination you have under consideration. Consider the collision of two deuterons, the nuclei of heavy hydrogen, each containing one proton and one neutron stuck together. They can bounce off each other without any evolution of energy, they can coalesce into a helium nucleus, or they can result in one proton and one triton, the triton being the nucleus of very heavy hydrogen and having two neutrons and one proton stuck together. The latter process happens much more often than the first.

Earlier I mentioned the numerous possible combinations of lighter nuclei to form slightly heavier nuclei. The probabilities of occurence of a few of these are well know, having been published in the scientific journals all over the world. The probabilities of occurrence of others are unknown as yet, at least no results have been published.

In addition to knowing the amount of energy evolved in the synthesis of a nucleus from lighter nuclei, and the probability of the formation of a particular nucleus when certain light nuclei collide, it is of the greatest importance to ensure these nuclear collisions will occur with sufficient frequency to evolve energy at such a rate that much of the available energy has been released before the material begins to fly apart. Earlier in my talk I mentioned that the electrons in an atom provided effective interference for the nucleus. What I meant was that when two atoms collide at temperatures even as high as in a blast furnace the electrons around each nucleus in the atoms are completely effective in preventing the nuclei ever getting close to each other. As an analogy one may think of a number of peaches at the bottom of a basket which is being shaken violently so that the peaches collide with each other frequently. However, the fruit of the peaches, representing the electrons make it impossible for the stones of the peaches representing the nuclei to get in contact with each other. Only by agitating the basket with extraordinary violence would it be possible to make the stones of the peaches burst through the fruit and touch each other. In matter at all attainable temperatures on the earth, the nuclei of colliding atoms never have a chance of touching each other because of the effective interference of the electrons. To overcome this interference and so make it

possible for the nuclei themselves to collide with each other, it is necessary to make the atoms move with extraordinary violence, and a way to effect this is to raise the temperature of the whole mass of material to many millions of degrees. This is perhaps the central problem of the hydrogen bomb, after selecting the nuclei which will give a good yield of energy on coalescing into a slightly heavier nucleus, and for which the probability of this particular synthesis is adequate. One way which has been repeatedly mentioned is to use a uranium or plutonium bomb as a starter to provide the very high temperatures needed and have the hydrogen in close contact with it. The difficulties seem to be many and great. Since hydrogen is a gas, it would seem necessary to use liquid hydrogen to secure the necessary density of material. The problems of liquefying hydrogen and keeping it liquid are extraordinarily difficult. Perhaps one could get around this difficulty by combining Li^7 and H^1 into lithium hydride which at least does not require to be held at extraordinary low temperatures. The nuclei of these atoms when in intimate contact, as is possible at high temperatures, can yield two helium nuclei with evolution of energy.

So far as I know, we are, in respect to the hydrogen bomb, in the same situation as we were in 1941 with respect to the uranium bomb. Theoretically at that time, it was just possible to make an uranium bomb if many conditions, then unknown, all turned out to be favorable. They turned out to be favorable and the bomb was made.

I want to recall my statement that, in the uranium bomb, only 0.1 per cent of the total mass disappears and this leads to the maximum energy that can be obtained theoretically per pound of uranium. Likewise in the formation of a helium nucleus out of lighter nuclei only a few tenths of one percent of the total mass disappears and this again leads to the maximum energy that can be theoretically evolved. Obviously if one could devise a process whereby all the mass of any material were converted into energy, the theoretical efficiency would be a 1000 times greater than that of the uranium bomb. So far as I know, no one has the slightest idea of how to realize this.

It is pertinent to quote a sentence from the Smyth report which dealt with the uranium bomb. "Initially many scientists could and did hope that some principle would emerge which would prove that atomic bombs were inherently impossible. This hope faded gradually." Smyth of course had in mind the uranium bomb. Maybe some principle or some technical difficulty may make the hydrogen bomb inherently impossible. Professor Urey recently stated that his guess was that there was a fifty-fifty chance of success in making a hydrogen bomb. Until mankind learns to solve its difficulties without appeal to war, it may be just as well if it was found that a hydrogen bomb could not be made. Unfortunately man's skill in science and technology goes ahead at an almost explosive pace while his ability to get along with his fellow men without war seems no better now than it was centuries ago.

So long as nations cannot work out acceptable procedures to settle differences between themselves without appeal to war, it would be unrealistic for us not to go ahead with the hydrogen bomb.

But at the same time, it is highly imperative to explore on a far wider scale than ever before, all possible avenues which may result in removing tensions and promoting cooperation between nations, and so remove, or at least greatly diminish, the danger of war. Although many highminded individuals and groups of individuals have made valiant efforts in this direction, it must be admitted that the scale and extent of their efforts, do not begin to compare with the scale and extent of the efforts we have put into the development of weapons for fighting a war. If the fears engendered by the terrifying possibilities of the hydrogen bomb spur us on to far greater efforts in the direction of settling disputes between nations by methods which do not include war, and if by some miracle these efforts are successful, then the hydrogen bomb may turn out to be a boon to mankind.

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WHAT TREE SHALL I PLANT

BY

AUGUST P. BEILMANN

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TRANSACTIONS OF THE
ACADEMY OF SCIENCE
OF SAINT LOUIS

WHAT TREE SHALL I PLANT?

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ACADEMY OF SCIENCE OF ST. LOUIS

The Academy of Science of St. Louis was founded in 1856 and chartered by the Nineteenth General Assembly of the State of Missouri by an act dated January 17, 1857. The objects for which the Academy of Science was founded are set forth in the Charter. They are threefold: first, the advancement of science; second, the establishment in the City of St. Louis of a museum for the illustration and study of the various branches of science; third, the creation of a scientific library. Membership in the Academy is not limited to those actively engaged as scientific workers; those interested in science are equally welcome.

An early and important museum of the Academy of Science was totally destroyed by fire in 1869. This appears to have been one of the significant museums of the country at the time, containing many type specimens. It would no doubt have been the nucleus for a great institution in the city of St. Louis. Later attempts to found a museum were not very successful until the present museum, 4642 Lindell Blvd., was established in 1943. There is a growing appreciation by the community of the scientific and educational work of the present museum. It is, however, only the beginning of the extensive science center planned for the future.

The Library of the Academy of Science of St. Louis originated soon after the founding of the Academy in 1856. By the turn of the century it was said to be the most extensive of its kind west of the Allegheny Mountains. The Library consists of approximately 70,000 volumes and pamphlets. Preserved here are the journals and reports of scientific organizations, learned societies and universities from all parts of the world covering a period of many years.

It should be stressed, however, that, not only are older publications found here, but the latest scientific literature is being received daily. The fact that some of the material housed here is very rare and not available elsewhere in the west emphasized the importance of this Library. Publications in all branches of both pure and applied sciences are represented. Its value to commercial and industrial concerns of the community is evident.

On the exchange list are 338 foreign institutions and 138 from the United States. Many of their publications are continuations of sets dating back many years.

The Library is available not only to members of the Academy but to all requiring its use.

INTRODUCTION

Most of the guides describing our shade trees, their adaptability and uses in the landscape, are based upon their behavior along the Atlantic Coast. No recent work has appeared which would serve as a guide for the Middle Western tree owner. This has had an unfortunate influence on tree planting since most of the texts available were written as a result of experience in the East. Trees which will stand dry weather in New England may not be happy during a dry period in Missouri. In the first case, a droughty period may last for only three or four weeks; even then, the nights are cooler, and the humidity quite high. A tree which shows some distress under those conditions may be seriously injured during a Middle Western summer which may be rainless from eight to thirteen weeks. During this time, night temperatures may approach ninety degrees; day temperatures exceed a hundred. To this add a thirty-mile-an-hour wind and a humidity reading of fifteen percent, and the term "dry spell" takes on an altogether different meaning.

Middle Westerners have rather blindly followed Eastern planting practices. This is shown most clearly by the distribution of Phloem Necrosis now found attacking the Elm in Kansas. It seems those entrusted with the planting of shade trees would have recognized that the Elm of New England was hardly suited to the heat and cold of the western prairies. It is hoped that the information contained in these pages will prove a challenge to the Middle Western tree grower, and that he will carefully consider the possibilities of those trees growing so well in his immediate neighborhood. By using many native species and varieties, he can diversify his plantings so that he is not left treeless upon the outbreak of a single disease. He can also add more than a little interest to his plantings, since very little thought has been given to the landscape value of winter silhouette, or the leaf texture and pattern in summer.

WHAT TREE SHALL I PLANT?

AILANTHUS

The Tree of Heaven (*Ailanthus altissima*) was brought over from China where it was held in high esteem. It is reported to "like people," and thus, it is perfectly at home in a slum or on a municipal dump. It is an extremely adaptable plant, capable of holding its own anywhere, and wonderfully reproductive. Perhaps if it was harder to grow, we would have some good things to report. It is not to be considered a good street tree, being generally short-lived on poor situations, but its stump sprouts so vigorously, and sprouts from the roots as well, that the death of the old plant merely means that one hundred offspring take its place. Under the best conditions, it may develop a trunk three feet in diameter and exceed fifty-five feet in height, but a tree that size merely indicates that that garden has experienced no ice or sleet storms in recent years. It is something of a botanical curiosity. As a street or lawn tree, it would be the last named on a list of suitable specimens. But remember it alone can grow in the congested factory districts.

ALBIZZIA

This might more accurately be called a shrub, yet a good specimen in the proper place will grow much larger than either Dogwood or Redbud. It is an unusual tree, producing powder puff flowers in late July and August when all other trees show the wear and tear of a St. Louis summer. For the small garden, it is superb as a lawn tree. It will rival the Magnolia in its flowering season. Mature specimens may have a trunk eight inches in diameter, a spread of twenty-five feet, and a height of twenty feet. It cannot be thought of as a long-lived tree, and it should be planted in an area that is protected from hot, dry winds; otherwise, it is adapted to almost any soil and may be transplanted either fall or winter. The variety "rosea" (*A. j. rosea*) is the hardier and not likely to winter kill.

ASH

This rather large family of trees, all of them reaching great size under proper conditions, is one of the forest trees in our locality. Generally, the White Ash (*Fraxinus Americana*) is planted for ornamentation and along the streets. When grown as specimens, they usually develop a round top, but the seed-bearing (pistillate) tree may fail to grow upright, and thus, it will develop into a low round-headed tree. The White Ash can be grown on the better soils. A closely related species which is capable of growing on the driest hills, the Blue Ash (*F. Quadrangulata*), should make a satisfactory street tree. It will stand the worst kind of exposure on our lawns. Ordinarily this is a tall tree, with a narrow crown as a rule, and generally growing rather slowly. On the whole, the Ashes have a limited number of enemies, but those pests attacking the Ash exclusively must be controlled. The most serious one is the Ash Borer, which drills holes in the trunk, and there are several species of scale insects capable of killing the smaller branches. Ash trees are not too easy to transplant. They do well in locations with adequate water, and they have no objectionable fruiting and flowering habits. The autumnal coloration is fair and offers a range of color from yellow to a deep purple. In winter the profile is quite satisfactory.

BASSWOOD

The trees belonging to this genus have a number of common names and are known just as frequently by the name Lime or Linden. They are all ornamental subjects and satisfactory either as street trees or lawn trees. Nursery catalogues list a number of varieties. The large Lindens (*Tilia*) are nearly all too large for planting where the root development may be restricted. For small gardens and narrow streets, some of the European varieties (*T. cordata, X T. europaca*) would be much more satisfactory. The Linden is without a fault, although it will be hard to establish on degraded sites. It is not difficult to keep such a tree in good health, and the maintenance would not be costly. In the Middle West it has no serious pest, although the rather soft wood may break badly in an ice storm. A twenty-five year-old plant may produce enormous quantities of flowers, but these are rather inconspicious, and neither the flowering

habit nor the production of seed is objectionable. They are best as park and lawn trees, to be admired from a little distance, and not planted too close to the house. The falling pollen and petals sifting through the windows may complicate house cleaning.

BEECH

These are trees best suited for the lawn and larger gardens. They would be unsatisfactory as a street tree because they produce a round wide-spreading top when grown away from their native woods. The ornamental forms of the European Beech (*Fagus sylvatica*) are less exacting in their requirements than our native ones. There are no finer ornamental trees than some of the Copper and Purple Beeches. If you have room and patience, some specimen of Beech should be planted. Few trees have a finer silhouette in winter. The dropping seeds are not objectionable. The fall coloration is a light-yellow and pleasing, and no very serious pests occur in this territory. Beeches are somewhat slow in their annual growth. But with patience and a great deal of mulch, the Beech will be found a satisfactory subject.

BIRCH

The Birches include some of the most spectacular lawn trees. Some are distinctive because of the snow-white bark. A few with graceful pendulous branching have no rivals and the winter habit of all species is most interesting. Unfortunately, the best of the White Birches are not happy in the Middle West. In fact, all varieties are short-lived in this area, except the one which is native (*Betula nigra*), the Red or River Birch of our river banks. If planted on very good soil and supplied with ample water, the Birches will all warrant planting, even if their life-span is quite short. There are many varieties available from nurseries. All of them are interesting, and all are worth a trial. Their greatest enemy is the hot dry summer. When a specimen begins to fail, maintenance is of little value. But they should be grown in the garden for their graceful habit and lovely yellow fall coloration, if for no other reason.

BUCKEYE

This genus (*Aesculus*) includes trees of all sizes from semi-shrubs to forest giants. The immense compound leaves and the interesting branching make them very satisfactory garden subjects. They are easy to transplant, grow rather rapidly, have comparatively few pests, and are not too particular about the soil. However, they do have faults. Some individuals and some varieties shed their leaves in midsummer and remain bare for the rest of the season. All of them produce a fruit of considerable size, and the old hulls, plus the large leaves, may make lawn maintenance difficult. Every member of the genus produces enormous quantities of flowers on large panicles, and in the case of an old tree, the ground beneath may be covered as the flowers mature and fall. It is one of the few trees having a wide range of color. The native semi-shrub (*Aesculus Pavia*) produces scarlet flowers, while the Ohio Buckeye (*A. Octandra*) has yellow flowers. Some of the hybrids developed as ornamentals have various shades of pink and yellow flowers.

BUCKTHORN

The plants belonging to this genus (*Bumelia*) are all very slow growing, but at the same time, they are all very long lived. When planted on good sites, the native species, the Wooly Buckthorn (*B. Lanuginosa*), grows into a small round-headed tree with contorted branches. The leaves are spatula shaped, and clothed with white hair underneath, thus giving the tree a whitish-green cast. The plant should be more widely used as a hedge in the Middle West. It is unusual in its ability to grow on dry situations, and a Buckthorn hedge will require no irrigation in a Missouri summer.

CATALPA

This tree, so widely planted at one time, has completely lost its popularity due to a number of bad habits. As a lawn tree, the dropping of the immense leaves make it difficult to keep the garden tidy. The flowers are produced so profusely that when they fall, they cover the ground. In fall, the ripening of the foot long seed pods presents still another problem in maintenance. The tree, as a whole, is not subject to much storm breakage even though the wood is very light-weight. The

young trees are easily grown from seeds. The Eastern Catalpa (*Catalpa bignonioides*) is a low, wide-spread tree of very limited value in the Middle West, and the little Umbrella Catalpa, so popular at one time, completes the list of these plants in this territory. There is one more species from west China which is hardy; Bunge's Catalpa (*C. Bungei*), and some forms which have been confused with the Yellow Flowered (*C. Ovata*); the first is a small tree, the second is a very tall forest species. The only one to be grown in our territory is the Western Catalpa (*C. speciosa*), and it is the best suited to the background planting of a large garden.

COFFEE TREE

This tree is noteworthy for its large leaves--the largest of any native tree, attaining a length of sixteen inches and made up of many leaflets. It is distinct also in that it has the stoutest branches of the native trees; the ends of the twigs are often one-half inch in diameter. It is ordinarily a tree of the river bottoms and the nearby talus slopes, although it may be found around old cabin sites in parts of the Ozarks. Only occasionally does it develop into the spreading habit deemed necessary for a shade tree. As an occasional tree in our woodlots, the Kentucky Coffee Tree (*Gymnocladus dioicus*) is usually without many side branches. It would be a particularly interesting garden subject and certainly could be used in the natural border. A wide spreading specimen would make an interesting lawn tree since the extremely stout branches and regularly curved, flaky bark would stamp it as an unusual tree. It may attain a height of ninety feet in good locations, but rarely exceeds half of this. It has no special bad habits and the winter silhouette is distinct from that of any other tree. The immense seed pods, half as large as a small banana, hang on through the cold winter.

CORK TREE

In the Middle West the term Cork Tree applies to one Asiatic specimen known by that name and described by the botanist as Phellodendron. The most satisfactory one is the Amur Cork Tree, (*P. amurense*), but at least five more specimens have been described. Like most of the Asiatic species, the growth habit is grotesque. In twenty-five

years it will grow into a low, very wide-spreading tree twenty feet in height and thirty feet across, with a trunk diameter of sixteen inches. This habit of spreading limits its use to large gardens, and perhaps its use along the street. It is extremely drought resistent and not especially subject to insect attack. The wood is very soft, and storm breakage is often severe. Great quantities of seed are produced each year and are quickly harvested by the birds. The seeds germinate readily and produce vigorous seedlings.

COTTONWOOD

There are about thirty species of Cottonwoods; a number of which are used ornamentally. The most common one, of course, is Lombardy (*Populus nigra italica*). This tree is so common that it hardly needs much comment, and any tall, very narrow, spire-like tree is usually this species. Several native ones are used; most of them are varieties of the Northern Cottonwood (*P. deltoides*). Any of this group are important largely because of the speed of which they grow. The Cottonwood has no place as a street tree and should be grown on our lawn only when full knowledge of its short life and its propensity to enter sewers is given consideration. The symmetrically balanced leaves and the construction of the petiole cause the leaves to flutter in the slightest breeze. Some members of the family, the Quaking Aspen (*P. tremuloides*) for instance, derives its name from this habit. But all Cottonwoods create the impression that there is a pleasant breeze blowing, even on the stillest and hottest day. On the whole, the Cottonwoods have not many enemies, but they are short-lived and should be interplanted with better species.

CRAB APPLES

The Asiatic species and varieties should find room in every garden. They are never large enough for street trees, but they can be used on the lawn or in borders, either singly as specimens, or in groups. There are many varieties available with flowers ranging from white through pink to red and foliage with green or some variation of red to purple. It is suggested that the Asiatic species and varieties only should be used, since they alone are immune to Cedar Apple Rust. This disease is

capable of destroying such native species as Bechtels Crab in two years. The Crab Apples have perhaps more enemies than many of the ornamentals; they serve as food for every native caterpillar, they have the usual quota of fungus diseases, and they are often seriously injured by borers and scale insects. However, they are so lovely when in flower, that the additional care is not too great a burden. Most of them can be thought of as requiring about as much room as an apple tree, although some forms grow much larger. On a good site, most varieties will grow about one-half foot higher each year.

DOGWOOD

The Dogwood (*Cornus florida*) would never be a street tree, although it may be used in a parkway. It is usually part of the understory of our forest or it grows at the wood-edge. In the primeval woods, it attained a size far greater than the Dogwoods we see today. The usual flower color is white, although pink and red ones can be obtained from nurseries. In all probability, even the White Dogwoods carry a little pink, since it appears that certain combinations of spring weather impart a very pale pink touch to our native white-flowered kinds. The Dogwood is not hard to transplant, nor is it especially hard to maintain when established. It is capable of growing without too much attention, and it produces a dependable display almost every year, but a heavy mulch is required when growing as an ornamental.

ELM

This is a large family of extremely important shade trees. Two serious diseases have focused national attention on them and until both the Dutch Elm disease and Phleom Necrosis can be controlled, it would be unwise to plant more Elms (*Ulmus sp.*), no matter how necessary they are, or how important they may be for a particular landscape effect.

EUONYMUS

The Spindle Trees as a group are either semi-shrub or small trees or climbers. The largest of the tree types able to stand our summers is the Winterberry Euonymus, (*Euonymus Bungeanus*). This species develops a round-top tree twenty-five feet high with a trunk diameter

of twelve inches in about thirty-six years. It has no place on the street, but it could be used in a parkway or a very large lawn. In all the members of this family, the fruit is distinctively colored and very attractive, although the flowers are generally small and relatively inconspicuous. Fall coloration is not especially good, except in the Yeddo Euonymus (*E. Yedoensis*). In some seasons, this species produces foliage of two striking colors. The upper surface of the leaf is scarlet, and the lower a clear yellow. The winged Euonymus (*E. alata*) is an interesting garden subject because of the strong corky wings on the branches. However, this cannot be called a tree, and it should be treated as a very large shrub.

GINKGO

Here is a superior street tree and equally as good as a lawn tree. Being an ancient species and believed to be the stepping-stone between the Conifers and the Deciduous trees, it has out-lived most of its peculiar enemies, and it has not been so widely planted that other enemies have developed a liking for it. It grows extremely large, reaching ninety feet in height at the rate of eight inches per year. With a little pruning, almost any Ginkgo (*Ginkgo biloba*) could be used as a street tree. The term "any Ginkgo" is used because it too has a grotesque growth habit, and all specimens fall into two general classes; those which grow rather narrow and tall, and those which spread and seem reluctant to grow upright. The tree will stand the atmosphere of conjested districts. It will stand much dry weather and a great deal of heat. It has only one fault--pistillate trees bear fleshy-fruit an inch in diameter which have an extremely objectionable odor. Either as a street tree or a lawn tree, the Ginkgo will prove satisfactory. The foliage is very interesting, fall coloration is good with a yellow as a predominant tone, and the twig tracery especially fine in winter.

GOLDEN RAIN TREE

Here is an Asiatic tree perfectly at home on the lawns of our county court houses. It is an excellent lawn subject and has the distinct advantage of flowering through July. The flowers clusters are very large, bright yellow and produced in such profusion that the

common name, Golden Rain Tree (*Koelreuteria paniculata*) refers to it when in flower. This tree does not grow tall, but produces a rather low, wide-spreading top with the contorted branches characteristic of most Asiatics. It may reach thirty feet in height in forty years, but it will have a spread even greater at that time. It is relatively free of pests and has no serious diseases, although the trunk commonly splits in the coldest part of the winter. Such "frost cracks" are characteristic of the tree in our territory and appear to do only a limited amount of harm. The seeds are easily germinated, the seedlings grow rapidly, and the tree often escapes from cultivation. The foliage is quite interesting and is unlike that of any native tree. The plant matures quickly and ten year old seedlings produce a full quota of flowers.

GUM

Under this title there are two distinct species. First is the Black Gum (*Nyssa Sylvatica*), the most brilliantly colored of all trees in fall. It can hardly be called a native of St. Louis territory, but it is perfectly at home well up into Pennsylvania. This tree has no bad fault. The foliage is clean and interesting. The flowers and fruit are so small and inconspicuous and it could be grown either on the lawn or on the street. Its use has been limited, not by any bad features, but rather because it is a most difficult tree to transplant. The extremely brilliant red foliage of fall would be repayment for any expenditure of time and effort to grow a specimen. It is a forest giant, ordinarily producing a long straight trunk with a rather small crown, but as a lawn tree, it will retain the lower branches and grow more slowly in height. It would not be a hard tree to maintain; even pruning would not be difficult.

The Sweet Gum (*Liquidamber Styraciflua*), the second tree with the name "Gum," is not at all related to the above species. This tree needs less of an introduction since it is being quite generally used as a lawn tree. It could be grown as well as a street tree, provided allowance was made for its maximum development. It, too, is a giant of the southern forests, growing a hundred feet high with a trunk diameter of three feet or larger.

The foliage is distinctive. The leaf has five points, greatly resembling a star. The leaves are large, glossy green through the summer and very effectively colored in fall. The colors ranging through the whole scale from yellow to purple. The chief objection to the tree for lawn use is the unsightliness of the large seed balls which may cover the ground beneath the tree in some years. The foliage is greedily eaten by most caterpillars, and during years when the Tussock Moth and Tent Caterpillars reach epidemic proportions, the Sweet Gum proves extremely attractive. These insects are readily controlled by spraying and they should not limit its use for either lawn or street purposes.

HACKBERRY

Several species of Hackberry (*Celtis*) can be used for shade trees. If properly grown, no more satisfactory tree can be found. The best species is *Celtis Ocidentaltis* and its varieties. These eventually exceed sixty feet in height, and a favored individual may develop a trunk four feet or better in diameter. On the whole, the tree has no bad habits. Leaf-raking is no more complicated by its presence, and the fruit is harvested by birds. The most serious insect pest is a gall causing witches brooms. The tree is seriously bothered by this pest making it unsightly, but by pruning and spraying, they can be eliminated. When left to develop on a lawn, the tree produces rather small branches and continues to grow upright. When mature, the lateral branches may continue to grow and eventually reach considerable size. Yellow is the dominant fall color, and for a very short period, the yellow is quite attractive, but leaves are shed rather quickly after changing color. Selected trees might very well be used either along the street or on the lawn.

HICKORY

In this genus, we have many of the common trees of the Ozark region. There are a number of species, however, and several varieties. As one might suspect, they grow from the flood plain to the dry hill tops. Generally, the Hickories are thought of as a part of a climax forest, and therefore, appear on the scene only in the final stages of the development of a wood lot. It would

be quite difficult to establish them as street trees; they would not take kindly to the bare soil of the planting strip, nor grow under the pavement edge. As a lawn tree, however, they are to be recommended. Some of them grow very large and all of them are long-lived. It is one of the few trees whose unfolding buds in spring are as colorful and interesting as the flowers of some of our best ornamentals. On the whole, the family has its quota of insect pests, but none of them so serious that one would hesitate to recommend the planting of Hickories. It is not a tree to be injured by late frosts. It is well adapted to Missouri springtime, and just patiently waits for settled weather before growing. The large fruits of some varieties may make them objectionable, but if there are any squirrels in the neighborhood, it will be unnecessary to rake hickory nuts from the lawn. One of the biggest Hickories adapted to very good soils is the King Nut, (*Carya laciniosa*). It resembles the Shag Bark Hickory, (*C. Ovata*), and both have the bark characteristically separating into long shaggy strips. These are both extremely large trees developing a trunk in excess of four feet in diameter. For drier situations, the Mockernut (*C. Tomentosa*), and its varieties will prove quite satisfactory. They make excellent lawn trees, having large leaves, growing tall, but differing from the first two in that they have tight-ridged bark. The term Pig Nut Hickory is applied to half a dozen species and varieties. Most of them are small trees growing on dry locations, and with small fruit and rather small leaves. Of these, only the Pig Nut or Bitter Nut, known technically as *C. Cordiformis,* would be suitable for lawn or street use. This is the Hickory with small buds, yellow in color, which are the best distinguishing feature. It may grow to immense size, but it does not tend to develop heavy side branches, and even as a specimen, it will grow much taller than it will spread. A nearly perfect shade tree for the larger suburban lot. The native Pecan (*C. Pecan*) can be found in the flood plain of both the Missouri and Mississippi Rivers. It is not likely to be happy as a shade tree. It requires the deep rich soil and the moisture found in the river valleys.

HOP-HORNBEAN

The little Hop-Hornbean (*Ostrya virginiana*) can hardly be considered a shade tree, yet it does grow tall enough to become the most important tree in the understory of a mature woods. It will not be happy if the taller trees are cut, and it usually dies if it is left standing as a specimen after such clearing. It has a place in the understory of a natural border. The foliage is Elm-like and the red-tipped hop-like flower is quite interesting in early spring. The tree grows rather slowly, but may eventually reach twenty feet in height with a trunk diameter exceeding six inches.

HORSE CHESTNUT

The Horse Chestnuts (*Aesculus Hippocastanum*) are not native, but they are showy, and on the whole, so satisfactory, that they can and should be used on streets, on parkways and lawns. While some of the varieties are not as vigorous, the species grows to be an immense tree; for this reason, it can not be used where the root development is likely to be restricted. The spring display of a large specimen, each branch tip carrying a large panicle of whitish flowers, is a sight never to be forgotten. A number of varieties are sometimes available from nurseries. The double-flowered specimen (*A. H. Baumanii*) is of slower growth and more compact form. The Pyramidal type (*A. H. pyramidalis*) still not too well known, might be used for narrow streets or smaller gardens. The types with varigated foliage are usually not satisfactory in this territory. In addition, there is one proved hybrid known as the Red Horse Chestnut (*X A. carnea*), which produces an abundance of pink flowers equally as large as the species. This tree tends to spread and would therefore be limited to large gardens or lawns. Not many insects attack the Horse Chestnut exclusively, but aphids are sometimes troublesome. The branching habit is good and they can weather most of our storms without too much injury. Under the weight of sleet, the branches bend and afterward, return almost to the original position without harm.

LOCUST

Under this common name, we have two distinct trees and the common names are reversed in the Middle West from

what they are in the East. To keep the record straight and follow "Standard Plant Names," we shall call (*Gleditsia triacanthos*), Honey Locust, even though this is the tree known as Black Locust throughout Missouri. As a street or lawn tree, it is partly satisfactory. It has the no mean advantage of being able to grow anywhere. It is at home along streams, but invades the dry rocky hills and manages to remain there for twenty years. In its proper habitat it becomes an immense tree, the trunk exceeding three feet in diameter, and attaining a height of one-hundred feet. It is a tree almost without an enemy and during a drout cycle, it conveniently sheds its leaves and thus reduces transpiration. The species generally produces immense thorns which are objectionable in the pasture and even more undesirable on the lawns. The rather unusual bark and branch tracery in winter recommends it as a tree for the border. However, the most objectionable feature, the immense thorns, does not occur in the variety known as the Thornless Honeylocust (*G. t. inermis*). On the whole, this variety seems a little less vigorous and perhaps shorter-lived, but it does not grow thorns, thus avoiding the one feature barring this tree for street or lawn use. The leaflets are so tiny that they constitute no maintenance problem. But the immense curled pods, up to eighteen inches long, may require additional effort to keep a lawn in good shape. In southeast Missouri, there is a single-seeded species called the Water Locust (*G. aquatica*). This tree combines the advantages of the thornless variety with one that produces small seeds. It is a distinct tree, hardy in the St. Louis region, but not too happy away from the swamps. It is almost unknown from nursery catalogues, and its advantages are imperfectly understood.

The Common Locust (*Robinia pseudoacacia*) differs from the foregoing in that it has gray-ridged bark instead of smooth black bark, and the flowers are white, while the foregoing species has quite inconspicuous yellow flowers. This tree has been widely used in erosion control. While not heavily armed, it is objectionable because it sends up so many root sprouts. This, of course, is an advantage in gully control work. If a few plants are established at the bottom of a ditch, it will not be long before the tree has invaded the adjoining

field. For this reason it can hardly be recommended as an ornamental; however, Besson's Locust (*R. p. bessoniana*) tends to produce far fewer root suckers, seems to be more floriferious, and has much better growth habit. It, therefore, has a place as a lawn specimen. The Common Locust has one serious pest, a large beetle which bores holes in the trunk; very few specimens escape attack. Control is rather difficult and generally the tree lives on in spite of the innumerable large galleries dug out of the heartwood.

MAGNOLIA

Many of the most important ornamental plants belong to this genera. Without exception, the members of this family are famous for their flowering habit. Some of these are native forest trees, and some are introduced from the Orient. One of the largest is the Cucumber Tree (*Magnolia acuminata*). This is a forest tree reaching ninety feet in height, growing from New York to Arkansas. Of all the Magnolias, it has the least conspicuous flowers, being so well-hidden by the foliage, but the immense red seeds protruding from the pods are very attractive in summer. It is a superior lawn tree, with all the requirements of a good street tree, except that it would be unhappy along the more highly-developed boulevards. It could be grown in the outlying sections of town, and along the less important roads. The Umbrella Magnolia (*M. tripetala*) only grows half as large as the foregoing, but it has enormous simple leaves. The flowers are much more conspicuous, and more heavily perfumed. It would be an excellent lawn tree, although it spreads too much for street use. The Sweet Bay (*M. virginiana*) has a wider distribution, and appears less critical of its surroundings than any of the Magnolias. It can hardly be termed a tree, yet it grows far too tall for a shrub, and root suckers so habitually that it usually has the appearance of a shrub. The flowers are white and hidden by the foliage, but the plant has no serious pest, and it has a place in the wetter portions of a natural border, or screen planting. The Bull Bay (*M. grandiflora*) is an immense Magnolia, growing every bit as tall as the largest tree in the South; it has achieved fame because of its connection with romantic literature. The flowers are white, fragrant, and immense. Unfortunately, the plant is

questionably hardy in the St.Louis area, although specimens in favored localities have lived for many years. The most conspicuous and common Magnolia in the St.Louis landscape is the hybrid Saucer Magnolia (*X M. Soulangeana*). This is hardly a tree, although in twenty-five years, it may form a mound twenty-five feet wide and eighteen feet high. It is most satisfactory as a specimen. This is only a partial list; there are several other good Magnolias well worth planting, but almost none of these are listed in nursery catalogues, and more planting and testing must be done before their behavior and hardiness is settled.

MAPLES

This is an extremely large group of over fifty species, and many more varieties. Not all of them are street trees. Some are small, and just barely reach tree size. Most of them are hardy in the Middle West, but only a few are satisfactory as street and lawn trees. The Norway Maple (*Acer platanoides*) becomes large enough for street use, however, it tends to spread too much, and thus it may have a place only on narrow residential streets, where it would be forced to grow upright. There are, however, a great number of varieties including two which could be used for street use. One tree, the Columnar Norway Maple, has upright branches, and the other is a Pyramidal Norway Maple of narrow growth habit. As a lawn tree, any variety of the Norway Maple can be used. They are trees with very large leaves, some varieties with variegated leaf blotches, some with red leaves; they all have a place in ornamental horticulture. The Little Hedge Maple (*A. campestre*), and its many varieties with yellow through green to purple leaves, all are suitable for gardens since these rarely exceed the size of a large shrub. The Sugar Maple (*A. saccharum*) is one of the forest trees of wide distribution in the eastern United States. Not all Sugar Maples are alike, and only those from the Ozark region can be successfully grown around St.Louis. The northern and eastern trees are not at all happy in this climate. This is probably the chief reason why Sugar Maple is so seldom used today as a street tree. A number of varieties have been identified and those of columnar habit would be especially interesting along streets. The Maples have their full share of insect

pests and diseases. The Verticillum Wilt does much harm in some years, especially to northern trees when planted in the Middle West. The Black Maple (*A. Nigrum*) is a somewhat slower growing edition of the Sugar Maple, with clear yellow leaves in fall. It is rather difficult to distinguish from the Sugar Maple, but it could be used as a street or lawn tree throughout the Middle West. On the whole, it tends to a more compact growth with shorter and smaller branches than the Sugar Maple. The Sycamore Maple (*A. Pseudoplatanus*) is one of the oldest Maples in cultivation and gardeners have had time to develop many forms and types. In the Middle West, it does not grow to great size. It is generally a tree not much over thirty feet, with large Sycamore-like leaves, and usually without enemies. It would make a superb lawn tree with either the normal green or purple variegated leaves. It spreads too much for street use, but it has a place in wider parkways. The Little Amur Maple (*A. Ginnala*) may reach a height of twenty feet, but normally, it is much smaller and can be thought of as a shrub rather than a tree. However, it can be grown with a single leader, and therefore, would become a splendid small tree for lawn use. Both the fruit and the foliage become brilliant red, the fruit when ripened and the leaves in fall. The Japanese Maple (*A. palmatum*) and its many ornamental forms are interesting and have a place in our gardens, but they are not suitable for street use. If grown with a single leader, they become interesting plants, usable even in the smallest gardens. The Scarlet or Red Maple (*A. rubrum*) is primarily a tree of the northern country. It is rather slow growing south of its normal range, and it may sucker so freely from the ground level that it can be forced into the habit of a tree only by very careful pruning. Eventually specimens grow taller and assume the characteristics of a tree, and about this time, they begin to exhibit the interesting red flowers and fruits. Several varieties are available; the most important is a columnar form likely to prove to be an excellent street tree. In the Ozark region, a small variety (*A. r. trilobum*) having a leaf with three lobes instead of the usual five can be found in some of the acid soil areas. This would make an interesting tree for the exacting gardener. The Swamp Red Maple (*A. r. Drummondi*) is perhaps the southernmost of the Red Maples. It is unusual

because of the white hairy underside of the leaves; generally a small tree and can be grown in the St.Louis territory. The Silver Maple (*A. Saccharinum*) is widely distributed over the country. It ordinarily grows along the water courses, but the ease with which it can be transplanted, the speed with which it reestablishes itself, the rapid growth rate, have made it one of the most popular street trees. In cities where "tree butchery" is practised, it is a special favorite. It fits in with such a program because it will tolerate "topping or pollarding." A few varieties are available; one with deeply cut leaves, a pyramidal type, and a weeping type. Little need be said about the advantages of using the Silver Maple without also listing its chief disadvantage --the branches will break in strong winds and under a load of sleet. Extremely large specimens can be found in river valleys, but as a lawn specimen or street tree, the life span is shorter and the size generally reduced. Box Elder (*A. Negundo*) has been widely planted in the Great Plains for shelter belt work. Under these conditions, it does not grow very rapidly, but is drought-resistant, and sheds all its leaves if dry weather continues. It is hardly worth the room in our gardens and would be most unsatisfactory on the streets. A number of varieties are listed but seldom obtainable from nurseries. On the whole, neither the species nor the varieties are satisfactory.

MULBERRY

Some form of Mulberry (*Morus*) should be included in every border planting because of its attractiveness to birds. Only one species is large enough to be used as a shade tree. This is the Red Mulberry, (*M. Rubra*)--native of the eastern half of the country. The large fruits which are eaten by all animals and birds would make it objectionable as a street tree, and partly so for lawn use. When allowed to grow as a specimen, it will develop a trunk over two feet in diameter, reaching a height exceeding thirty feet, with a wide-spreading crown which shades out all competition. The tree grows very rapidly; which is a decided advantage, but the leaves are a favorite food of all caterpillars. This lessens its attractiveness as a lawn tree.

OAK

The Oaks are all grouped under this heading rather than placed throughout the alphabetical list. They are also grouped for convenience. The Oaks should be used much more extensively than they have been, and gathering them into a chapter should make an evaluation of their suitability much simpler.

White Oak This is probably the finest of all trees. It has no equal as a shade tree, and there are no better lawn trees. Only storms of cyclonic proportions are able to cause damage. The White Oak (*Quercus alba*) grows over much of the eastern United States, but unfortunately, it does not transplant readily, nor does it grow well without a layer of leaf mulch over the root system. The gray flaky bark is interesting throughout the year. The production of acorns in some seasons may be a disadvantage in areas without squirrels. The fall coloration is variable; some specimens are very good, and some quickly drop their leaves. The tree can grow to gigantic size and often has a spread greater than its height. Individuals may live for several centuries. The White Oak is quite free from pests and has only one disadvantage; the fact that it is hard to transplant and reestablish. Once established, however, it can be made to grow fast enough for the most impatient gardener.

Burr Oak Here is another Oak with many advantages as a street and lawn tree. The Burr Oak (*Quercus macrocarpa*), growing from the swamplands to the loessial hilltops, is one of the most adaptable of this group of trees. It transplants much more readily than the White Oak, grows every bit as fast after transplanting, and some specimens exhibit good fall coloration. The winter silhouette is good, showing extremely massive and rugged characteristics. The darker bark, heavily ribbed and corky branches, the deeply incised leaves, and the immense acorns make this an outstanding tree. As a rule, it is completely without insect enemies, and it is rarely attacked by diseases. One could not grow a finer shade tree, although for street use, the Burr Oak may spread too much. If properly transplanted and supplied with water and food, it can be made to grow more than a foot in height each year of its youth.

Swamp White Oak The Swamp White Oak (*Quercus bicolor*) always appears to be intermediate between the White and Burr Oak in many of its characteristics. It is a tree of the river valleys and other better-watered situations. It is also a tree of greater adaptability than the White Oak and can be transplanted much more easily than that species. When growing as a specimen, the rather light flaky-barked branches tend to become pendulous with the branch tips attempting to grow horizontally. Very few insects attack this tree and it is not especially susceptible to disease. The Swamp White Oak would probably be a better street tree than either the White or the Burr Oak. Since it does not develop such immense side branches, it would tend to grow upright and spread only a fourth as much as the two Oaks it resembles. It should be tried as a shade tree. The winter branch tracery is distinct and very pleasing, and autumnal coloration is often good.

Chinquapin Oak Here is one of the smaller white Oaks with a distinct leaf, and it actively competes with Red Cedar for a toe-hold on the dry Ozark hills. It does not grow as large as the foregoing trees, but it can stand more dry weather than any Oak in the Middle West. If given an opportunity on the lawn, it develops into a wide-spreading tree. The Chestnut-like foliage of the Chinquapin Oak (*Quercus Muhlenbergii*) is distinct. The color is good throughout the summer and may reach a clear yellow in fall. The tree shows the usual resistance to diseases and insects. The growth rate is slower than those Oaks from the lowlands, and it appears to delight in a heavy mulch.

Post Oak The commonest White Oak through most of St. Louis County is the Post Oak (*Quercus stellata*). It is a native of the dry Ozark hills and is either a good tree or an inferior tree, depending upon the fertility of the site. Experience indicates that it will hold its own for many years while the hill on which it grew is being subdivided and converted into residential districts. The Post Oak tends to hold its dry brown leaves throughout the winter. The acorns are very small, the fall coloration only fair. It would be hard to establish as a street tree, but it would be very satisfactory on the lawn.

Northern Red Oak This is a tree of wide distribution and ready adaptability. The maximum size and the growth rate of the Red Oak (*Quercus borealis, maxima*) depends on the depth and fertility of the soil. It will prove more satisfactory as a lawn tree and less so as a street tree. The great size when mature limits its use to large gardens and wide parkways. A related tree, called Shumards Red Oak (*Quercus Shumardii*) grows along the water courses, and would be much more satisfactory as a shade tree than the Northern Red Oak. Neither of these trees have objectionable habits nor do they have many insect enemies. The difficulties encountered in transplanting and reestablishing them are the only limitations upon their use.

Pin Oak The Pin Oak (*Quercus palustris*) is being widely used as a shade tree. It is one of the most easily transplanted and has no serious objectionable feature as a shade tree. The symmetrical growth habit makes it one of the few which are satisfactory for street use. Ordinarily it produces many small side branches and therefore grows taller and spreads less than most of the other Oaks. When planted in very dry locations, it may develop chlorosis; this is a dietary deficiency and may be corrected by the injection of Iron into the trunk. The fall coloration is not especially good, but the winter silhouette is unusual and quite unlike the White Oaks. It would be unsatisfactory as a street tree, but it has a definite place in parks and parkways where ample room is available.

Shingle Oak This one of the last Oaks to disappear when a woodland is developed into real estate. The leaves are distinct, having an entire margin--the only Middle Western Oak with this characteristic. It is a tree of wetter situations, although it may be found on dry hills. In many respects it resembles the Pin Oak. It has the same kind of branching, but rarely grows as large; although in youth, it grows as rapidly as any other Oak. It might be used as a street tree in wetter localities, and it has a place as a shade or lawn tree.

Two more Oaks which might be used as far north as St. Louis are the Willow Oak (*Quercus Phellos*) of the

Southern swamp, and the Overcup Oak (*Quercus lyrata*) of similar situations. The Willow Oak has very small leaves; otherwise, it resembles our Shingle Oak in all its characters. It would be an excellent lawn tree, but of questionable value along the street. The Overcup Oak has the growth habit of our Swamp White Oak. It appears to be perfectly winter-hardy near St. Louis. But it tends to produce long branches which sweep the ground. It is therefore a suitable lawn tree and would be satisfactory in a parkway. Both the leaves and the acorn cup are distinct and should be quite an addition to the list of trees available to the serious gardener.

OSAGE-ORANGE

Few trees have been planted so extensively as the Osage-Orange (*Maclura pomifera*). Portions of the old "hedge" fences can be seen on many Middle Western farms today, where they are often the best and sometimes the only game cover left on the farms. Unlike most of our shade trees it originally had a very limited distribution - it was found only in the Red River Valley of northeastern Texas; but it has proven its adaptability by doing very well hundreds of miles from its home. This tree can be used on the street, the lawn and certainly in the wood lot; it grows quite rapidly and may develop a trunk over two feet in diameter in fifty years. The wood seems never to rot and thus the tree is never damaged by poor pruning - the smaller branches are armed with stout spines and this too tends to keep the "wood butcher" away. The tree should be used much more frequently even though the heavy fruits constitute something of a hazard. This and the fact that caterpillars relish the foliage are the only objectionable features to the general use of a tree which does not break in storms and never decays.

PAGODA TREE

Pagoda Trees (*Sophora japonica*) are easily grown from seed; they begin to flower when quite young, with the result that they become more attractive each succeeding year. The tree produces a dense shade and would be most effective as a specimen when the lowermost branches touch the ground. In our territory, the leaves remain active until late fall, making the tree almost semi-evergreen. The flowers begin to open about July first,

and for a two-week period, almost clothe the tree in white. Aside from the other advantages, this habit of producing flowers when the Middle West is beginning to feel the effects of dry weather is a strong recommendation for their wide use. Pagoda Trees are not attacked by many insects, and they have no serious diseases. They may prove somewhat hard to establish, but they should grow well where ever the better shade trees can be expected to grow.

PERSIMMON

The Persimmon (*Diospyros virginiana*) has come to be considered an invader of abandoned fields. Most people who encounter it in the field think of it as hardly more than a shrub. Actually, the tree grows very large and quite rapidly. If allowed to grow undisturbed on the lawn, it will reach a height of fifty feet, a branch spread of forty feet, and trunk diameter exceeding two feet. As a lawn tree, the most serious objection might be the tendency of the smaller branches to break off when they die. The fruit, of course, is edible and eaten by many animals and birds. The tree produces a great many flowers in May and June, but these are inconspicuous and well-hidden by foliage. If allowed to develop normally, the Persimmon would be an excellent lawn tree and any objectionable fruits would be harvested by small boys and squirrels.

PLUMS AND CHERRIES

This is an extremely large family containing many trees of great ornamental interest, and just as many producing the commercial fruits. The largest tree in the family, and about the only one suitable for street use is the Black Cherry (*Prunus serotina*). This would be an excellent lawn tree, attractive to birds and with very fine twigs approaching the Birches in their graceful slenderness. All of the Japanese Flowering Cherries belong to this group, but very few of them are satisfactory in the Middle West. One small tree of interest, because it unfolds its leaves four weeks ahead of other trees, is the Harbinger Cherry, (*Prunus Padus commutata*); this plant, along with most of the rest of the family, is best grown in the shrub border. Two plums that would make small lawn specimens are native to Middle West fence rows. One is the Hortulan Plum (*Prunus hortulana*), and the other,

the American Plum (*Prunus americana*). Both of them produce rather large fruit, and both are extremely floriferous in early spring.

REDBUD

One hardly thinks of Redbud (*Cercis canadensis*) as anything but a small tree of the wood edge. Actually, it has been known to develop a trunk over a foot in diameter, and attain a height of over fifty feet when growing in the river bottoms. It would not make a shade tree, but it should find a spot in every garden. The growth rate is rather slow, and if given sufficient room, it may grow to a height of thirty feet in forty years. If allowed to grow in this fashion, the trunk will be a foot thick and the lowermost branches will sweep the ground. When the normal red variety is used with the white variety, (*C. c. alba*) few combinations of plants can equal the beauty of these small trees in springtime. Ordinarily, the Redbuds are not hard to grow, but they can be seriously injured in very dry weather and they should be heavily mulched.

SASSAFRAS

Under the conditions which obtained in the virgin woodland, the Sassafras (*Sassafras officinale*) developed into just as large a tree as any other member of the forest. The Sassafras is also considered, and most frequently seen today, as an invader of abandoned fields. From this habit, it might be considered as a tree not too critical of the soil or the site. Actually, it reaches its maximum development only when grown in good localities. It may then develop a trunk of three feet in diameter and exceed a height of seventy feet. The autumnal coloration is very good, and the yellow flowers in early spring are equally as attractive. The unusual foliage and branching habit make it a tree that should be widely used for shade. It has only one fault; it tends to produce many suckers from the roots. To any one accustomed to the Sassafras brush of an abandoned field, the suggestion that it be used as a lawn tree will come as a great surprise, but it should be used and should be tried. The tree has many interesting features and only a few bad habits.

SERVICE BERRY

This, too, is one of the small trees of the deep woods and wood edges. The Service Berry (*Amelanchier canadensis*) is usually quite difficult to grow as an ornamental, but it often reaches a height of thirty feet, and is especially attractive when in flower in the very early days of spring. If used as an ornamental and planted in the semi-shade of an old tree, it would be a welcome addition to any garden. The clean light-gray bark, showy, white flowers, and the lemon-green opening leaves are very attractive. It would not be satisfactory as a street tree, but it might very well be used in the more extensive plantings of a parkway.

SOAPBERRY TREE

The Western Soapberry Tree (*Sapindus Drummondii*) is the hardiest member of a large tropical family. Found sparingly in the Southwest, it is drought and heat-resistant and should find a place as a tree of the parkway and small garden. In size and spread it is in keeping with low-roof modern architecture--it will not dwarf a "ranch-house" built on a small lot. The panicles of yellow semi-translucent berries resemble a bunch of grapes, with hardened drops of varnish in place of edible fruit. The tree may reach a height of forty feet, but it is always much smaller in Missouri and Kansas. The foliage is interesting and reasonably insect proof; the tree is winter hardy as far north as southern Iowa.

SYCAMORE

There are so many sycamores (*Platanus*) planted on our streets and lawns that this tree needs little introduction. Of course, it has many advantages as a street tree, or it would not be so widely used. It has certain disadvantages, too, but long-time acquaintance has caused us to forget its defects. It lends itself admirably to city-foresters who "top" trees, and it is equally at home under power and telephone lines where it can be "topped" year after year. It is unfortunate that the only rule governing the selection of street trees has been the one which asks how much can a tree stand. Since it is so widely used, the exacting gardener will not plant another specimen. The tree is not without enemies. A fungus disease (*Anthracnose*) attacks the small branches

early in spring and cause defoliation. Most caterpillars will feed on its foliage, and a serious trunk rot of the London Plane has been found in the East. In addition to these disadvantages, it sheds some "fuzz" from the opening buds which is quite irritating to the nose and throat.

TULIP TREE

The Yellow Poplar or Tulip Tree (*Liriodendron Tulipifera*) is a very satisfactory shade tree in the Middle West. It can be used on the street as well as the lawn. It grows to immense size and it is one of the important forest trees. The square-cut leaves are distinctive. The flowers are large and they alone would make the tree an outstanding ornamental except that they are produced at a time when the tree is in full leaf and they are hidden by the foliage. The tree has a number of leaf spots and is not entirely free of insect injury, but in spite of no care, individual trees are able to live a long time. It is not a tree for the small garden, and may spread too much for the narrow street, but it has a definite place and will be very satisfactory along boulevards and parkways. The most serious objection to its use might be the brittleness of the wood during a sleet storm, but in this respect, it is not as dangerous as some of the trees commonly planted along the streets. It will not grow on the poorest site; some moisture and a fair degree of fertility are necessary for good growth. With our common street trees being killed by serious diseases, it is high time that the Tulip Poplar be given a chance to demonstrate its value.

WALNUT

It may seem strange that one should propose the Walnut (*Juglans nigra*) as a shade tree, but trial would prove that it is quite at home on the streets and that it would be a magnificent dooryard tree. It has certain very definite advantages not shared by any other tree. First of all, Blue Grass can be grown up to the very trunk, which cannot be done with many other trees. Secondly, it produces its greatest amount of shade in mid-summer when it is needed the most. Ordinarily, the leaf buds open late in spring, thus, the grass gets a good start before the tree beings to cast much shade. The reverse is true in fall. The Walnut is one of the first trees to shed

its leaves, and thus allow the grass time to complete its growth in the fall sun before winter sets in. Walnuts, of course, require a good deal of room, but careful pruning will develop a proper shape for any situation. There are certain disadvantages--the tree has a number of insect pests. The most important is the Walnut Datana, whose larva spin a web, housing several hundred caterpillars, destroying the foliage while safety inclosed in their tent. Arsenate of Lead is a certain control. Some objection might be raised to the fruit falling on pedestrians and automobiles, but ordinarily, the squirrel population of a town or city will be equal to the task of harvesting the fruit before it reaches a dangerous size. For lawn trees, one might use the named varieties, since they produce superior nuts, but for street use, just any American Walnut will be satisfactory. While the tree is not exacting in its soil requirements, we cannot expect good growth when it is planted on a degraded site.

WILLOW

The Willows(*Salix*) are all trees requiring more than the usual amount of water. They grow extremely fast and their life span is usually short. They have a definite place in landscape architecture since no other tree has quite the characteristics and habit of the Willow. They are the first to unfold leaves in Spring and the last to shed them in Fall. Almost innumerable varieties occur, but only a few are found in nursery catalogues. The weeping kinds, with long pendant branches are unique and have no rivals. Some Willows grow into forest trees, others never grow very large and some are shrubby. There is much variation in foliage, in both size and color. Willows would not be satisfactory as street trees--they are altogether lacking in strength and are too easily damaged by storms. Willows have some insect pests, but these are no more difficult to control than those on other trees.

YELLOW WOOD

Here is a poorly known tree having some outstanding characteristics. The Yellow Wood (*Cladrastis lutea*) is hardy in the St. Louis region and would develop into a lawn tree of great size and beauty. The bark is steel-gray, smooth, and quite distinct. The flowers are

produced in innumerable terminal panicles. They are produced so freely that the tree deserves wider planting because of this feature alone. If given sufficient time, it will reach thirty feet in height and should spread even farther. To be successfully transplanted, a heavy mulch or manure must be used and maintained until the tree is established. Some pruning must be done each year to produce the kind of tree required for that location. Many of the lower limbs must be removed if head room for pedestrians is needed; otherwise, the tree will develop branches that sweep the ground.

ZELKOVA

The Zelkova (*Zelkova serrata*) has Elm-like foliage, a short trunk subdivided into many upright limbs, giving the tree a round-topped shape. The branches are very slender, quite flexible, but not easily broken in storms. In the Middle West, the tree is not likely to exceed thirty feet and if allowed to develop without pruning, the branches may spread as much as forty feet. As a lawn tree, it would interest the serious gardener. The bark is smooth, reddish-brown, forming rows of small scales. The flowers are relatively unimportant, but the light-yellow fall foliage casts a light shade, thus it becomes a tree suitable for specimen planting, since grass can be grown somewhat inside the branch spread.

EVERGREENS AND CONIFERS

The Middle West is rather limited in its choice of good and dependable Evergreens. Of course, one might use almost any species or variety in a foundation planting; we can see in the residential sections of any town many instances where forest trees such as the Spruces and Pines were planted in the restricted area of a foundation close to the buildings. One can often observe Mugo Pines which have outgrown their allotted space on either side of a walk. Pfitzer Juniper, often used as a point plant with no thought of its ultimate development, can be found almost completely blocking the walk way. In a foundation planting, one can use almost any Conifer provided he is ready and willing to use the axe just as soon as the forest tree grows out of bounds. However, the use of Norway Spruce, Colorado Blue Spruce, Austrian Black Pine, and the large Junipers in a foundation planting indicates either a complete lack of even an elementary knowledge of trees, or a careful disregard of everything associated with the use of plants except the art of salesmanship.

WHITE PINE

Here is a tree which grows so well in the Middle West that it can be considered a shade tree in the fullest sense of the word. The White Pine (*Pinus Strobus*), a north country tree, was one of the forest giants all the way from Michigan to New England, and is today the fastest growing pine in the region about St. Louis. It should be planted on good soils and given a great deal of room, since it will grow eighteen inches higher each year and may reach fifty feet in sixty years. To attain this height, most of the lower limbs must be pruned off. If given sufficient room, the tree will maintain its lowermost branches and have a spread about one-third its height.

HIMALAYAN WHITE PINE

This tree shows great promise in the Middle West and is one of the most beautiful Pines in all the world. The

foliage is extremely soft; the needles are long, with a pleasant bluish cast--creating the impression of a very superior White Pine. Certain forms of the tree are hardy. The one known as Griffith's Himalayan Pine (*Pinus Griffithii*) appears to be the best of those which have found their way to this country. It is not a tree which will be happy in a restricted area nor will it do well on poor sites, but in a proper location it has no rival.

PONDEROSA PINE

The Bull Pine or Ponderosa Pine (*Pinus Ponderosa*) is an important timber tree in the West. Obviously, it must eventually become a big tree. On good soils in the Middle West select trees grow to immense size. The needles contrast strongly with those of the White Pine, being longer, stiffer, and a darker green. It produces a much denser shade than White Pine and requires a great deal of room for its maximum development. In youth, it grows rapidly and is tolerant of our hot summers.

BLACK PINE

Here is an old introduction which will grow rapidly for thirty years; slow down suddenly, and exhibit all the characteristics of an aged Pine. The Austrian Black Pine (*Pinus nigra*) is one of the few Conifers which can exist in the polluted atmosphere of the cities. If given ample room and allowed to develop as a specimen, it will exceed forty feet in height with a spread almost as great, and retain its lowermost branches. The foliage is very stiff, dark in color, and the needles sharp pointed. The winter candles are white and quite interesting. It is perfectly at home in the Middle West and can be used as a specimen, a group, or part of a border planting.

SCOTS PINE

Perhaps no other tree has been so widely planted as the Scots Pine (*Pinus sylvestris*). The failure of the tree has had an unfortunate influence on the use of large Conifers in this area. The Scots Pine varies tremendously over its range across Europe, and seeds from some regions produce very inferior trees. The situation became so alarming that European foresters drafted the first Seed Certification Law in the nineteenth century. This was designed to prevent the planting of more inferior

strains. Many such strains have been planted in the United States. They produce short-lived trees with an inferior trunk, attaining maturity in twenty-five years, and then die. In landscape work the Scots Pine might be very valuable. The cinnamon-red bark is distinctive and the short blue-green twisted needles are a welcome note in the border. It is unfortunate, however, that the best strains--those from Latvia--are hardly known in this country. This strain (*Pinus sylvestris rigensis*) has a long life, a straight trunk; and if given room will become more valuable each year.

JAPANESE RED PINE

Here is a small Pine of grotesque growth habit, with multiple leaders, and short light-green foliage. It is capable of producing many seeds, but is relatively short-lived. The Japanese Red Pine (*Pinus densiflora*) has the advantage of doing well on poor soils for twenty years, but it should be used only in the border or as a group, or possibly interplanted among better trees. As a temporary tree in the landscape, it is very valuable, but it must not be considered a permanent part of the planting.

JAPANESE BLACK PINE

This is a better and longer lived tree than the above. The Japanese Black Pine (*Pinus Thumbergii*) also has a grotesque growth habit which, however, could be of considerable landscape value. The foliage is dark, the side branches somewhat pendulous; and the tree grows quite rapidly. It produces seeds when twenty years old, and it would make a very interesting specimen tree especially in springtime when each branch is tipped with an immense white candle, the largest candles of any Pine. It will do quite well on poorer soils and tends to hybridize quite freely with Japanese Red Pine.

JACK PINE

If the Jack Pine (*Pinus Banksiana*) is planted in a good location, it will grow half as fast as the White Pine. It is not too highly regarded even in its native territory, but becomes quite picturesque as it grows older. It belongs to the two-needle Pines and therefore bears a strong resemblance to several other species; a

short-lived tree in the Middle West, it has a definite place in a woodland border.

SCRUB PINE

The Virginia Pine (*Pinus virginiana*) rarely exceeds forty-five feet. It is widely distributed along the East Coast, and seldom attains the symmetrical outline we expect in our ornamental Evergreens. It is perfectly hardy, capable of withstanding hot dry summers and is not injured in the winter winds. It has grown well and reseeded itself on one spot in Missouri. When the tree reaches maturity, it takes on an air of rugged indifference.

SHORT LEAF PINE

It is paradoxical that one should recommend Pines from all over the world as suitable for the Middle West and discourage the planting of the only Pine native to this region. The Short Leaf Pine (*Pinus echinata*) is a most important forest tree in the Pine belt beginning fifty miles south of St. Louis. As an ornamental, it leaves much to be desired. When planted north of its natural range, it becomes slower growing and even less symmetrical. It is more difficult to establish than many other pines in the region about St. Louis. It has a place only in the plantings of a serious gardener who wishes to grow the one native Pine.

COLORADO SPRUCE

This western species is one of the most popular of Evergreens. The Colorado Spruce (*Picea pungens*) and its blue varieties need very little introduction. Nursery-grown trees are easily transplanted and not very difficult to grow, and stand our summers quite well with a little additional irrigation. It must be remembered, however, that it is a forest tree growing as tall as one hundred-fifty feet and therefore, it must be given sufficient room.

WHITE SPRUCE

This tree, growing from the Badlands of the Dakotas to Alaska, and even reaching Labrador, should be at home in the boiling summers of the St. Louis territory, but strangely enough, it is not as happy as one might expect. Particularly the Black Hill Spruce (*Picea glauca densata*)

cannot stand the luxury of rain in June or July. They are happier in drier seasons. There are a number of varieties of White Spruce available, and all of them develop into trees of great beauty, if by chance they were planted in the right location. Ordinarily, they are slow-growing and never entirely happy in the immediate vicinity of St. Louis.

NORWAY SPRUCE

A tree from Europe, that has been in cultivation for centuries, and a great many forms have been described. There are dwarf kinds, pendulous types, one without side branches, and some with various colors of leaves. It is a fast growing tree used as an ornamental and also as a windbreak. The Norway Spruce (*Picea Abies*) while quite satisfactory, eventually loses its lowermost branches and becomes less symmetrical with age. In youth it may develop into a charming specimen, but eventually it requires some planting about the base to replace the limbs which have been lost.

TIGERTAIL SPRUCE

This small slow-growing Spruce from Japan has light-green leaves and takes its name from spiny-pointed needles. The Tigertail Spruce (*Picea polita*) appears able to withstand the greatest exposure and the longest dry cycle. It is therefore a good tree for the Middle West, but it may not reach ten feet in height in twenty years. It has a definite place in landscape and should be given a trial.

The Spruces are all worthy of attention. Most of them would do better north of St. Louis, and all of them would do better north-east of St. Louis. In those areas, one might grow Serbian Spruce (*Picea Omorika*) which is the Christmas Tree on Yuletide postcards. There are two more from Asia. The Oriental Spruces (*Picea orientalis*) and *Picea Koyamai*. Both of these are doing well in sheltered locations. They are quite distinct and are worth the extra effort required to grow them.

COLORADO FIR

Some forms of this tree can be grown in the Middle West. It can hardly be termed a shade tree, but under

the best of conditions, it may develop well and become an important ornamental. When well-grown, it is one of the most beautiful of Firs.

DOUGLAS FIR

While not a true Fir, the Douglas Fir (*Pseudotsuga taxifolia*) has been widely used in the South as an ornamental, and is perfectly at home in the Middle West. It is a magnificent tree, growing to a height of thirty feet in twenty-four years. Free of insect pests and disease, but very shallowly-rooted, it requires some protection from the wind. It is not a tree for the Ozark hilltop, nor is it a plant for the foundation group. When it reaches a height of thirty feet with branches clear to the ground, the shallow-root system which is characteristic, can not hold this mass of foliage in a strong wind, therefore, Douglas Fir should have more than a little protection from storms. Nursery-grown Douglas Fir do very well in the Middle West, and they should be given every opportunity to prove their worth.

CYPRESS

Here is one of the oldest of Conifers and one that is so adaptable that it can grow almost anywhere today. While a native of the southern swamps, it can be carried far north of its present range and it will grow as a specimen on a hilltop. As shade tree, it has few rivals. It grows rather rapidly, about a foot in height a year; does not spread too wide, casts full shade in summer, sheds its leaves in fall, and has no single bad habit. The unfolding leaf buds in spring are very beautiful, and the winter silhouette is extraordinarily good. A street lined with Cypress (*Taxodium distichum*) would be unique and would become more beautiful each year.

HOLLY

Perhaps no part of any native tree is so widely used as the foliage of the Holly (*Ilex opaca*). The wide-spread use, of course, accounts for its being gathered almost to extinction in Missouri. No finer lawn or park tree can be grown. But the tree grows too slow and is generally unsuited for street use. In its native woods it grows just as tall as its neighbors and may develop a trunk over sixteen inches in diameter and reach a height of

fifty feet. Such a specimen does not have the symmetrical growth so characteristic of lawn specimens. This tree should have a place in every garden large enough to give it room to grow, but care must be exercised to obtain the pistillate or berry-producing plant. If Holly is heavily fertilized with an organic manure and given sufficient water, it will grow nine inches taller annually for a great many years.

RED CEDAR

The Middle West is the home of Red Cedars, and almost every type of the fifteen-hundred named varieties will do well in the heat and dry weather of summertime. The Red Cedars or Junipers (*Juniperus*) have two serious insect pests. The Bagworm feeds on all varieties, but it can be controlled if sprayed between May 15 and June 1 with Arsenate of Lead. Red Spider is an occasional pest, and it can be checked with contact spray. Not many of the Red Cedars would make street trees, but they might very well be used in parkways, lawns, a border-planting, or a windbreak. Some of the most important ornamentals are members of this genus, and some kind of Juniper will fit into almost any planting plan. They are reasonably resistant to atmospheric pollution. They can stand heat and dry weather and the tree forms may live for six-hundred years.

This does not complete the list of Evergreens which could be used in the Middle West. For instance, one could find a place for the Larch (*Larix*), The Golden Larch (*Pseudolarix*), the Arborvitae (*Thuja*) and the Hemlocks (*Tsuga*). Individual plantings of all of these can be found in the Middle West and some of them have reached a size entitling them to be considered as shade trees. However, they are not so easily grown. Their adaptability is limited, and only under the best of conditions can they grow rapidly enough for most tree owners. Needless to say, any of these, when well grown, are worth driving miles to see, but they are not likely to prove satisfactory in the hands of most planters.

PLANTING

The only satisfactory tree to plant is the best grown nursery tree that can be obtained. Poorly grown stock at bargain prices or trees dug from the woodland rarely have the kind of root system which favors quick reestablishment. Nursery-grown trees are often quite expensive, but when well-grown, they have a compact fibrous root system better able to quickly overcome the shock of transplanting. Nursery practices usually include some form of cultivation or root-pruning which favors the production of an immense number of fibrous roots and prepares a tree for moving. The same tree, when grown in the woodland usually has few small roots and depends on heavy long anchor roots for its needs. When such a tree is dug, a far greater proportion of the active roots are lost and it transplants with difficulty.

Large trees are usually balled and burlapped and the ball of nursery-grown stock is usually filled with roots. No great deal of preparation is needed to dig a hole for such a tree. It is only necessary that the hole be dug much larger than the ball, and that the best soil obtainable be packed in around the ball. In the absence of any good garden soil for this purpose, it would be possible to improve poor soil with the addition of shredded and rotted cow manure, rotted leaf mold, or horticultural Peat. As much as half the volume needed to fill the hole could be these organic materials. If the nursery-grown plant has a deep ball, it will be unnecessary and may even be harmful to loosen soil in the bottom of the hole and thus allow the balled-plant to settle. It would be better to set the ball directly on the undisturbed soil. Fill the remaining space with good soil and apply a heavy mulch. In the process of digging and handling balled-plants, a good deal of water is lost from the ball, even though the ball is wrapped in burlap. To compensate for this loss of water, it is a good practice to allow a hose to run while the back filling is being done. After the

saturated soil and compost mixture has been allowed to settle and drain, additional filling is needed to overcome settling and the remaining soil is thrown up as a small levee forming a saucer about the tree. This levee should have a diameter a little greater than the original hole. Its chief purpose is to prevent the loss of water when irrigating during the first year. This saucer also serves to keep the mulch in place and should have a capacity large enough to hold sufficient water to thoroughly wet the ball. Very large trees can be moved in this fashion and they may need staking and bracing. Large trees can only be moved with adequate equipment, since a big tree and the ball of earth about the roots may weigh as much as six tons. Usually the Arborists capable of handling such planting stock are competent to guy and brace the tree, and expect to do so using steel rope and anchors. The home owner, planting the small evergreen, may not need steel cables or heavy anchors. A one or two inch square stake and a short piece of hose to encircle the trunk, and some wire may be all that is needed. With sufficient preparation, one can move forest trees to lawns or streets. Plans for this must be laid several years in advance of the actual moving. Woodland trees do not have a compact root system and therefore are hard to reestablish. A particularly good root system--one approaching nursery stock--can be developed in several years by root-pruning. The usual procedure is to dig a trench about the tree and fill it with the best mixture of rotted manure and top soil obtainable. About one-third of the trench is excavated and filled in each of three succeeding years. The tree is then ready for digging in the fourth season. This preparation requires a good deal of planning and considerable patience, but in some cases, the time may be shortened to two or three years. Without this preparation, the wild tree may require many years to recover after being planted in its new location.

MAINTENANCE

PRUNING

The development of a good shade tree begins in the nursery, but the tree planter is seldom concerned with nursery practices. He purchases a tree with the intention of growing it, and growing it to maturity. He takes over where the nurseryman leaves off, and he assumes that the correct branching has been established for that species or variety. In the nursery, only enough pruning has been done to train the small tree. After it is reestablished in its permanent home, a certain amount of corrective pruning will be needed every few years. Pruning is an art and detailed instructions concerning its many ramifications are beyond the scope of this work. Just a few suggestions having universal application can be given. First of all, every shade tree should be grown with a single trunk; even though that trunk is only a few feet tall. In the case of some Magnolias, even this short trunk may be lost through the growth of additional side shoots from the ground level.

Pruning, then, will be an endless task. The only compensation will be a structurally sound tree, with a proper distribution of scaffold branches, having the maximum ability to withstand the force of winds and storms. Ordinarily, every tree loses some of the lower branches. Even specimens whose branch-tips sweep the ground will have lost many of the lowermost branches and will continue to lose a few until maturity. The towering Oak of the forest, with a long straight trunk and small crown, will develop a short trunk and a larger crown if allowed sufficient room for maximum development. Close-planting favors competition between individual branches of the same tree, between the branches of adjoining trees, and between the trees themselves. It is necessary then that a fairly clear picture of the mature tree be kept in mind before any pruning is attempted.

The formation of sharp "V" crotches as the main trunk subdivides is the underlying cause of the greatest storm damage. Such sharp forks are not structurally sound; when they are torn apart by storms, the damage is quite severe. Often, half of the tree is lost in such cases. The Elms, Maples, Ash, Locust and many others have the tendency to develop these forks. On the other hand, the Pin Oak, Sweet Gum, and White Oak, rarely produce multiple leaders. The strongest branch is one that leaves the main trunk at a right angle. Storms may break such limbs, but the damage is not irreparable and only a small part of the tree is injured. Some trees could not be grown without sharp crotches; but in these cases, an effort should be made to develop as long a trunk as possible. Early pruning will do much toward establishing the proper distribution of branches along a structurally sound trunk.

If a tree has been trained to grow in the right direction by pruning, it will not be necessary to remove a great number of interfering branches. In the language of the tree surgeon, these are branches, because of their proximity to other branches, that tends to retard the development of their neighbors, but they eventually lose out in the race for light. In the Pin Oak, or trees of that growth habit, it may mean a branch immediately above or below another branch almost identical in size; eventually, one of these must be sacrificed. In the Gingko, it may mean horizontal branches with right-angle secondary branches tending to compete with either one or a half dozen similarly placed branches. Their removal might be called "anticipatory pruning." Since in the normal course of events, one of these branches will shade out one or more of its neighbors. This kind of pruning can be carried on regardless of season. The removal of the doomed branches early in the life of the tree allows the remaining branches to develop their full size and there is never a need to wait for the proper season.

The proper season to prune, it has been said, is "when your knife is sharp." Like many old sayings, there is an element of truth in this statement; however, it should be interpreted as applying to the condition of the tools at all seasons, since there is never a better time

than "now" to remove a dead branch. Pruning-cuts tend to heal fastest if done in spring. Experimental pruning-cuts on Soft Maple showed that the opportunity for infection by wood-destroying fungi was reduced by half when the cuts were made in April. Cuts made after the spring growth healed completely; but not before another twelve months exposure of the unprotected wood of the pruning wound. While it is true that pruning scars made in early spring heal most rapidly, it would be a mistake to delay the removal of a dead or dying interfering branch.

The tools required for pruning can be left to personal choice. It is necessary only that they be designed for the job, and that they make a clean smooth cut. The wrong tool may do much damage to the adjoining bark. After a branch has been removed, some heartwood and sapwood are usually exposed, and these must be protected from rot. So far no one has perfected a paint or dressing which is one hundred percent effective in preventing the entrance of decay spores. No dressing will give complete protection for any length of time, but every cut should be painted with the best material available.

SPRAYING

In the Middle West, insect outbreaks are not unknown, but the need to carry on elaborate spray programs is not nearly so important as in some other sections of the country. Of the leaf-chewing insects, the Bagworm, the Tussock Moth, and the various species of tent caterpillars are the greatest problem. The Bagworm may appear locally every year, the Tent Caterpillars appear about every five years, and the Tussock Moths have a longer cycle. On occasions, all of these appear simultaneously, and spraying becomes very necessary. Arsenate of Lead can be used for all of these. Direction tables will not be given since the manufacturer's recommendations, as printed on the container, can be followed without reservation.

A number of scale insects are common. The Kermes Oak Scale has the widest almost universal distribution. Plantings which have had no care whatsoever may also be injured by Scurfy Scale, Terrapin Scale and San Jose Scale. The Elm Bark Louse may often be found locally,

and in some seasons, Wooley Aphids may require special spraying. Some ornamentals are favorites of the Red Spider. The control of these insects is somewhat more difficult than the spraying required to destroy caterpillars. Contact sprays rather than stomach poisons are required. Scale insects, Red Spider, Aphids, must be killed by contact spray. These are materials which kill through their action upon the skin or the respiratory system of the insect. Heavy-bodied oils may be needed for Scales in winter, and in summer, lighter oils give effective control. In addition, Pyrethrum, Rotenone, and combinations of these with newer products are effective on Red Spider and Aphids. Because of the vast amount of work being done on insect control, no specific instructions for the control of the sucking insects will be given. Recommendations and special information can be obtained from the Etomology departments of State Universities, from Horticultural Societies, Botanical Gardens, and County Agents.

Borers are not uncommon, but they usually attack those trees which are low in vigor. The most serious kinds are the Flat Head and Round Head Borers which may seriously interfere with establishing newly-planted trees. Large deciduous trees planted with a ball may require additional trunk protection. Shielding the trunk from the sun with boards or wrapping the trunk with paper or burlap strips will reduce the possibility of injury.

FEEDING

A good deal of information is available on the feeding of trees in the Middle West. Experimental work has indicated that shade trees suffer from no single deficiency such as nitrogen, or phosphorus, or potash. It appears rather, that all of these materials are needed, and that the proper fertilizer is one that contains nitrogen, phosphorus, and potash. It is certainly true that not every bit of ground requires exactly the same treatment to grow grees. On the other hand, there is not a satisfactory practical way of determining what the deficiency may be for our average shade tree. For this reason, the complete fertilizer will continue to be used. The amount of fertilizer to apply depends upon a number of features --the soil type, and its history before the present trees

were planted, a history of this soil since the planting was finished, the depth, character, classification, and the degree of soil disturbance should be taken into consideration. A fertilizer containing ten percent Nitrogen, eight percent Phosphorus, and six percent Potash, known commercially as 10-8-6 tree food, has given excellent results in the Middle West. Undoubtedly, this formula contains too much potash for specific cases and the amount of Phosphorus may be greater than is needed to obtain the maximum growth from the complete fertilizer. Until a simple analysis to determine the exact deficiency becomes available, it is recommended that the complete 10-8-6 fertilizer continue in use.

The amount of fertilizer to apply to a particular tree depends partly upon the vigor of the tree, its past history, its size and age. Dosages have been variously calculated. It has been suggested that one or more pounds per foot in height be applied; that a similar amount per inch of diameter be used; but neither method gives us a picture of the size of the tree. Perhaps the best formula would take several measurements into consideration. The author has recommended that the sum of three dimensions be taken as the pounds of tree food needed. Thus, if a tree is twenty feet high, has a branch spread of fifteen feet, and a trunk diameter of six inches, it would require the sum of these three figures, or forty-one pounds of fertilizer. Regardless of recommended dosages and formulas, the person applying tree food must add another intangible ingredient called experience. This fourth material added to the formula is extraordinarily important.

Fertilizers can be applied in several ways. The easiest and simplest system for the tree owner is to punch holes with a crowbar in concentric circles under the branch spread. These holes are to be twenty-four inches deep and from twenty-four to thirty inches apart. The first row of holes begins immediately under the branch-tips and the next circle is three feet inside of this. If more room is needed, another circle is made three feet closer to the trunk. One pound of the dry fertilizer is poured into each hole. These may then be filled with peat moss, top-soil, or leaf mold. It is a

good practice to apply sufficient water to dissolve the fertilizer. This method requires the punching of many holes, since a big tree might require two hundred pounds of fertilizer. Instead of the crowbar, one might use a post-hole digger. This would permit an increase in the amount of organic fertilizer that could be used.

Commercial Arborists are using both air and water pressure and special guns to force diffusion of the fertilizer underground. These methods have many advantages. They eliminate the serious objection of soil compaction caused when the crowbar is used. Both the hydraulic and the pneumatic tools force the fertilizer into soil crevices causing a diffusion of material that can not be obtained in any other way. As a result, trees respond much more quickly, and few roots are burned by coming into contact with a pocket of fertilizer.

Commercial fertilizers are most necessary in a good tree maintenance program. They are capable of stimulating a tree to the point where it grows vigorously. Such stimulation may last for several years, but commercial fertilizers do not cause a great change in the soil. They have little effect on the physical structure. Organic fertilizers, on the other hand, play a complex role in soil chemistry, and their behavior is thoroughly illustrated in the extensive literature on the subject. They are soil improvers; they tend to reestablish the soil flora. Most small trees would be benefited if organic fertilizers were used. When used as a mulch, organic manures very rapidly reestablish the top soil. Most mortality of newly planted trees and the failure of established trees is traceable to soil depletion and the destruction of the top soil. With a new man-made top soil in the form of a mulch over the root area, almost any tree can be expected to flourish.

TREE SURGERY

There are times when older trees require additional help aside from the usual pruning, spraying, and feeding. Trees on a playground may have the soil above the roots so compacted that there is no exchange of gases between the soil and the atmosphere. Very old trees may need additional water which can be furnished only by some

elaborate underground system of irrigation. Trees which have been allowed to develop sharp forks, or because this is a characteristic of their growth, have developed crotches of such size that breakage would mean a destruction of half the tree, also require special help. Then too, there are trees which have had their protective armor--the bark--broken through injuries, or even pruning cuts, and these have begun to decay. All of these problems might rightly be termed "tree surgery" since they involve the use of specialized materials, techniques, and trained operators.

Soil aeration is one of the standard procedures of the arborist. Soils which may have become water-logged, shallow soils with a tendency to "puddle," soils that have been rendered toxic to trees by leaking gas mains, and the soils about very old trees may need aeration, or deep cultivation. The corrective procedure in all of these cases have been to use a jet of compressed air, released at the tip of a gun some distance underground. This procedure can shatter the hardest soils and keep them open for some time. It has the effect of deep plowing without moving the soil. The same procedure can be used in aerating a gas filled soil.

The unfortunate tendency to produce sharp forks in some species and the production of such forks through the common failure to train trees correctly, eventually calls for some elaborate way of bracing the tree. The standard procedure has been to install galvanized cables well up in the top. Ordinarily, these cables are strung from limb to limb in an effort to develop a geometric pattern so that the thrust of wind against one branch or side of the tree will be absorbed in part by all the other branches in the tree. On occasion, special-threaded rods are run through the trunk at the crotch which is the fulcrum. Such special steel rods reduce the grinding and crushing effect observed here in windstorms, and thus shift the fulcrum to a lower portion of the trunk, which is much more capable of bearing the force of the wind.

The equipment used in cabling and bracing has been developed especially for tree use. The installation requires considerable agility and ability to climb, and

more than a little practical engineering. This necessary maintenance operation would seem better left in the hands of the trained arborist.

When there is a break in the enveloping sheaf of bark, the armor of a tree is pierced and it becomes vulnerable to attack by wood-rotting fungi. It does not matter how this interruption of the protective and living covering occurred. Bark broken from the trunk by a lawn mower or the wood exposed by pruning cuts are equally susceptible to infection. No pruning paint will protect this wood indefinitely. If the exposed areas are large and years must elapse before the wound callus heals the injury, we can be sure that infection will start. For a good many years, the happy solution to this problem consisted of chiseling out the decayed wood and filling the cavity with concrete or rubber or asphalt or in Forsyth's day, with a concoction of cow dung, wood ashes and lime. Experience over the past twenty-five years has shown that all cavity-filling operations are not successful. In most cases, the work has been called successful if it prolonged the life of the tree and furnished a surface on which the new bark could grow. However, the experience of the exponents of the "open cavity system" have been equally successful in arresting decay. The filling of a cavity or the maintenance of an open cavity are best left in the hands of a professional arborist. With some of the newer organic fungicides, this phase of tree care may again take its rightful place in tree preservation. The present use of power tools which eliminates the costly chisel and mallet work has resulted in a reduction in the cost of this elaborate operation.

BALD CYPRESS AT LAKE CHARLES, LA.

THE BALD CYPRESS AS A PARKWAY TREE IN
TOWER GROVE PARK, ST. LOUIS

THE PISTILLATE FORMS OF THE MAIDENHAIR TREE
MAKE A GRAND STREET TREE

REDBUD IN SPRING--THE COMBINATION OF BOTH THE
WHITE AND THE RED FORMS ARE MOST ATTRACTIVE

THE LARGE FLOWER OF THE TULIP TREE

THE TULIP TREE SHOULD BE USED MUCH MORE
FREQUENTLY AS A STREET AND PARK TREE

TWISTED PODS OF BLACK LOCUST

THE SINGLE-SEEDED BLACK LOCUST FROM THE SWAMPS.
A TREE WITHOUT MANY BAD HABITS--
NO THORNS AND SMALL SEED PODS

THE FORKED-LEAF WHITE OAK, VERY SATISFACTORY SOUTH OF ST. LOUIS

THE LITTLE WHITE AND CREAM HONEY POTS MAKE THE PERSIMMON ATTRACTIVE TO BEES

STAMINATE AND PISTILLATE FLOWERS OF THE SYCAMORE

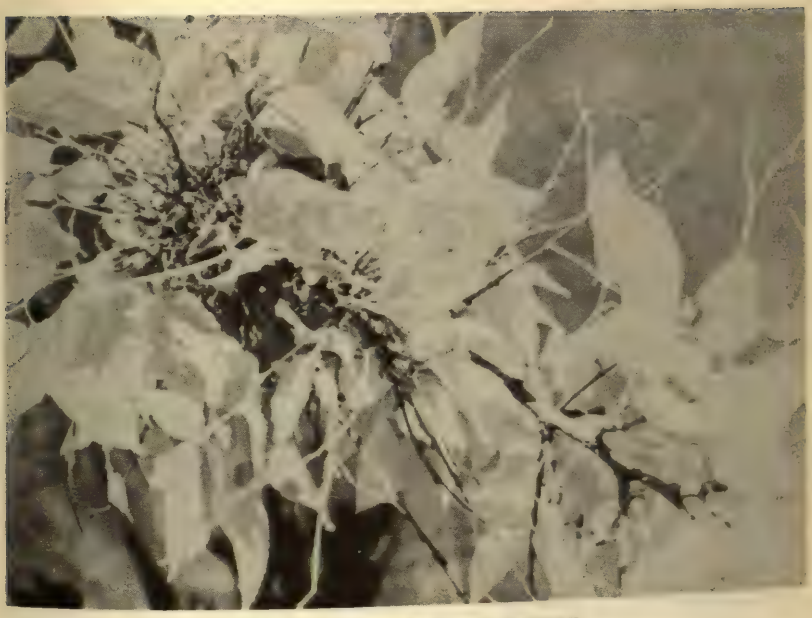
THE INCONSPICUOUS LEMON-WHITE FLOWERS OF THE
KENTUCKY COFFEE TREE (REDUCED 1/2).
THE MIDDLE RIB OF THE LARGEST COMPOUND LEAF IS SHOWN

THE PINK "POWDER PUFF" FLOWERS OF
ALBIZZIA JULIBRISSIN, ROSEA

THE FRUIT OF THE BITTERNUT HICKORY IS SMALL AND
NOT ESPECIALLY OBJECTIONABLE

SWEET GUM FRUIT

BASSWOOD FLOWERS ARE ESPECIALLY ATTRACTIVE TO
NECTAR LOVING INSECTS



WITCHES BROOM OF HACKBERRY

THE HOP-LIKE FLOWERS WHICH GIVE THE
HOP HORNBEAN ITS NAME

THE FRUIT OF THE SUGAR MAPLE

THE COLORFUL FLOWERS OF THE SOFT MAPLE - ONE OF THE FIRST FOREST TREES TO BECOME ACTIVE IN SPRING
STAMINATE (LEFT) AND PISTILLATE (RIGHT) FLOWERS OF THE SOFT MAPLE

MATURING FRUIT OF SASSAFRAS

STAMINATE (LOWER) AND PISTILLATE FLOWERS
OF THE CYPRESS

AMERICAN HOLLY ALONG THE SABINE RIVER IN EAST TEXAS

SMOOTH, SOMEWHAT FLAKY BARK OF A
RIVER VALLEY SOFT MAPLE

THE FRUIT OF SHINGLE OAK

THE LARGEST BUR OAK IN THE UNITED STATES
GROWING NEAR EAST PRAIRIE, MO.

OPENING FLOWERS OF HACKBERRY

THE OPENING FLOWERS OF THE SWEET GUM

THE GREEN INCONSPICUOUS FLOWERS OF THE WALNUT--
WHICH OPEN WHEN THE WEATHER HAS SETTLED

THE INTERESTING FLOWERS (LEMON-YELLOW AND WHITE)
OF THE SUGAR MAPLE APPEAR WHEN SPRING IS
JUST AROUND THE CORNER

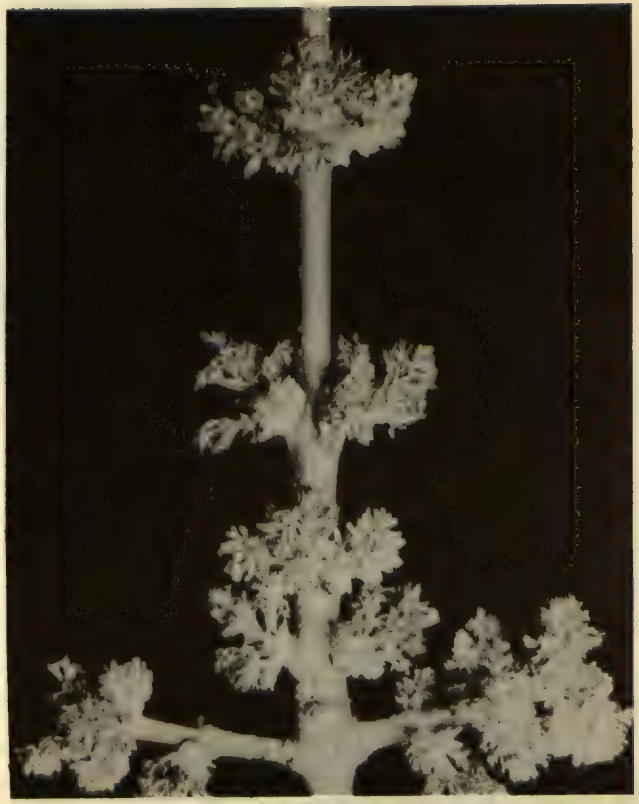
THE GOLDEN RAIN TREE AS A PARK SUBJECT

A MATURE SHAGBARK HICKORY

THE PIN OAK IS AN EXCELLENT SHADE TREE
FOR ALL BUT THE DRIEST SITES

THE BITTERNUT HICKORY GROWS INTO A
WELL SHAPED SHADE TREE

THE UNFOLDING FLOWER BUDS OF BURR OAK--
TYPICAL OF ALL WHITE OAKS



THE OPENING STAMINATE FLOWERS OF THE WHITE ASH

THE CLEAN BRANCHING AND INTERESTING FOLIAGE OF THE THORNLESS BLACK LOCUST

THE FORM AND HABIT OF THE KENTUCKY COFFEE TREE SUGGEST A POSSIBLE USE ON WIDE STREETS AND PARKWAYS

THE AWESOME AND DANGEROUS SPINES OF THE ORDINARY BLACK LOCUST

THE WESTERN SOAPBERRY TREE - A SMALL TREE FOR THE SMALL GARDEN AND LOW-ROOF ARCHITECTURE

OPENING PISTILLATE FLOWERS OF AMERICAN ASH (X 1/2)

THE INTERESTING FLOWERS OF THE BLACK CHERRY

THE BLACK CHERRY IS A GOOD SHADE TREE,
BEST SUITED TO LAWN USE

THE THORNY FORM OF BLACK LOCUST IN WINTER CONDITION

A JUNIPER CAN GROW ANYWHERE

THE OSAGE ORANGE ATTACKED BY MISTLETOE IN RED RIVER COUNTY, TEXAS

MAGNOLIA GRANDIFLORA IN EAST TEXAS

THE OSAGE ORANGE AS A BOULEVARD TREE

	Size				Use				Soils						Exposure				Permissable Sunshine			Annual growth at 20 yrs. on a fair site			Annual growth at 40 yrs. on a fair site			Type		Strength			Maintenance		Wind protection required from	Remarks
	20 yrs.		40 yrs.																																
	Spread	Height	Spread	Height	Boulevard	Street	Lawn	Background	Wet	Normal	Dry	Fertile	Not Exacting	Light	Heavy	Maximum	Normal	Minimum	Not Exacting	Maximum	Normal	Minimum	Terminal Branches	Trunk Diameter	Fast	Medium	Slow	Terminal Branches	Trunk Diameter	Fast	Medium	Slow	Upright	Spreading	Easily Broken	Withstands wind & sleet	Very strong	Costly	Normal		
Ailanthus	20 ft.	30 ft.	35 ft.	55 ft.		X		X					X			X				X			12 in.	1/2 in.	X			8-10 in.	3/8 in.		X		X	X				X	none	A Weed
Albizzia	20 ft.	22 ft.	...	...			X	X		X							X				X		14 in.	1/4 in.			X	...	...				X	X				X	none	
Ash, White	15 ft.	30 ft.	25 ft.	35 ft.	X	X	X	X		X		X			X		X				X		10 in.	3/8 in.			X	8-10 in.	1/4 in.		X		X	X		X			X	none	
Ash, Blue	8-10 ft.	22 ft.	12 ft.	35 ft.	X	X	X	X		X	X	X	X	X		X				X			6-8 in.	1/4-3/8 in.			X	6-8 in.	1/4 in.			X	X		X				X	none	
Basswood, American	15 ft.	24 ft.	25 ft.	40 ft.	X	X	X			X		X		X	X		X			X			8-12 in.	1/2 in.		X		6-10 in.	3/8 in.		X		X		X				X	none	
Basswood, Large-leaf	20 ft.	30 ft.	30 ft.	50 ft.	X	X	X			X		X		X			X				X		10-12 in.	1/2 in.		X		8-10 in.	1/2 in.		X		X		X				X	southwest	
Basswood, European	20 ft.	22 ft.	30 ft.	40 ft.	X	X	X			X				X			X				X		6-10 in.	3/8 in.		X		6-8 in.	1/4 in.				X	X					X	southwest	
Beech, American	6 ft.	15 ft.	10 ft.	35 ft.	X	X	X			X		X		X			X				X		6-8 in.	1/4 in.			X	4-6 in.	1/8 in.			X	X		X				X	southwest	
Beech, European	8 ft.	12 ft.	14 ft.	25 ft.	X		X			X		X		X			X				X		6-8 in.	1/4 in.			X	4-6 in.	1/8 in.			X	X		X				X	southwest	
Birch, Red	10 ft.	25 ft.	25 ft.	35 ft.			X	X	X	X		X			X		X				X		10-12 in.	1/2 in.	X			8-10 in.	1/2 in.	X				X					X	none	
Buckeye, Ohio	12 ft.	20 ft.	30 ft.	45 ft.	X		X	X		X		X		X	X	X				X			8-12 in.	1/2 in.			X	8-10 in.	3/8 in.			X	X		X				X	none	
Buckeye, Red	8 ft.	15 ft.	...	...			X	X	X	X		X		X			X				X		2-4 in.	1/8 in.			X	...	...			X	X	X				X	none	
Buckthorn	10 ft.	20 ft.	20 ft.	30 ft.			X	X			X		X		X		X			X			4-6 in.	1/8 in.			X	4-5 in.	1/16 in.	X			X		X				X	none	
Catalpa, Eastern	25 ft.	22 ft.	30 ft.	30 ft.	X		X	X		X			X				X				X		6-8 in.	1/2 in.	X			6-8 in.	3/8 in.	X			X	X		X				X	southwest	
Catalpa, Western	8 ft.	25 ft.	20 ft.	50 ft.			X	X		X		X		X	X		X				X		8-10 in.	1/2 in.	X			8-10 in.	1/2 in.	X				X		X				X	southwest	
Catalpa, Bunge's	5 ft.	15 ft.	...	...			X	X				X				X				X			4-6 in.	1/16 in.			X	...	...			X		X				X	none	
Catalpa, Yellow-flowered	10 ft.	15 ft.	...	...			X			X		X				X				X			6-8 in.	1/8 in.			X	...	...			X	X					X	none	
Coffee Tree	10 ft.	25 ft.	15 ft.	35 ft.	X	X	X	X	X	X		X		X	X	X				X			8-10 in.	1/2 in.	X			6-8 in.	3/8 in.	X			X	X		X				X	none	
Cork Tree	25 ft.	22 ft.	35 ft.	30 ft.			X	X			X		X		X	X				X			8-10 in.	1/2 in.	X			6-8 in.	3/8 in.	X			X	X		X				X	southwest	
Cottonwood, Northern	28 ft.	35 ft.	35 ft.	70 ft.				X	X			X	X		X	X				X			8-10 in.	1/2 in.	X			6-8 in.	3/4 in.	X			X		X				X	none	
Cottonwood, Lombardy Poplar	8 ft.	25 ft.	8 ft.	40 ft.				X	X			X	X			X				X			10-20 in.	3/4-1 in.	X			10-20 in.	3/4 in.	X			X		X				X	none	
Crabapple													X										10-14 in.	1/2 in.	X			10-14 in.	1/2 in.	X			X		X				X	southwest	Varieties are extremely variable in habit.
Dogwood	10 ft.	20 ft.	12 ft.	25 ft.			X	X				X				X					X		4-6 in.	1/16 in.			X	4-6 in.	1/16 in.			X	X		X				X	southwest	Not recommended at present.
Elms																							6-8 in.	1/4 in.		X	X	6-8 in.	1/3 in.		X	X	X		X				X	southwest	
Euonymus, Winterberry	12 ft.	15 ft.	20 ft.	25 ft.			X	X	X	X			X			X				X			4-6 in.	1/8 in.		X	X	4-6 in.	1/8 in.		X	X	X		X				X	southwest	
Euonymus, Yeddo	12 ft.	15 ft.	...	...			X	X	X	X						X				X			4-6 in.	1/8 in.		X	X	4-6 in.	1/16 in.			X	X		X				X	southwest	
Euonymus, Winged	18 ft.	20 ft.	25 ft.	25 ft.			X	X	X	X		X			X	X				X			6-12 in.	1/2 in.	X		X	6-12 in.	1/2 in.	X	X		X		X				X	southwest	
Gingko	20 ft.	30 ft.	25 ft.	50 ft.	X	X	X					X			X	X				X			6-10 in.	1/2 in.			X	6-10 in.	1/2 in.		X		X		X				X	southwest	
Golden rain	20 ft.	20 ft.	30 ft.	35 ft.	X	X	X						X			X				X			6-8 in.	1/2 in.			X	6-8 in.	1/2 in.		X		X		X				X	southwest	
Gum, Black	15 ft.	30 ft.	20 ft.	40 ft.	X	X	X	X				X			X	X				X			8-10 in.	1/2 in.			X	6-8 in.	1/2 in.		X		X		X				X	southwest	
Gum, Sweet	20 ft.	25 ft.	25 ft.	35 ft.	X	X	X	X		X		X			X	X				X			6-8 in.	1/2 in.			X	6-8 in.	1/2 in.		X		X		X				X	none	
Hackberry	8 ft.	25 ft.	20 ft.	38 ft.	X	X	X		X	X	X	X			X	X				X			8-10 in.	1/2 in.			X	6-8 in.	3/8 in.		X		X		X				X	none	
Hickory, Kingnut	8 ft.	20 ft.	16 ft.	45 ft.	X	X	X		X	X		X			X	X				X			6-8 in.	1/2 in.			X	6-8 in.	1/2 in.		X		X		X				X	none	
Hickory, Shagbark	8 ft.	25 ft.	20 ft.	50 ft.	X	X	X		X	X		X			X	X				X			6-8 in.	1/2 in.			X	6-8 in.	3/8 in.		X		X		X				X	none	
Hickory, Mockernut	10 ft.	25 ft.	25 ft.	40 ft.	X	X	X		X	X		X			X	X				X			8-10 in.	1/2 in.			X	6-8 in.	3/8 in.		X		X		X				X	none	
Hickory, Bitternut	15 ft.	22 ft.	25 ft.	35 ft.	X	X	X		X	X		X			X	X				X			8-10 in.	1/2-3/4 in.	X	X		6-8 in.	1/2 in.	X	X		X		X	X	X		X	none	
Hickory, Pecan	20 ft.	25 ft.	30 ft.	40 ft.	X	X	X		X			X			X	X				X			8-10 in.	3/4 in.	X	X		8-10 in.	1/2 in.	X	X		X		X				X	none	
Hop-Hornbeam	10 ft.	18 ft.	15 ft.	25 ft.			X	X			X	X					X				X		4-6 in.	1/4 in.			X	4 in.	1/8 in.			X	X		X				X	southwest	
Horse-Chestnut	15 ft.	25 ft.	25 ft.	50 ft.	X	X	X			X		X				X		X	X	X			6-10 in.	1/2 in.			X	6-8 in.	3/8 in.			X	X	X	X				X	southwest	
Horse-Chestnut, Bauman's	10 ft.	18 ft.	...	...		X	X			X		X				X				X			4-6 in.	1/4 in.			X	...	...			X		X				X	southwest	
Horse-Chestnut, Red	15 ft.	20 ft.	25 ft.	30 ft.	X		X			X		X				X				X			4-8 in.	1/4 in.			X	4-8 in.	1/4 in.		X	X	X	X				X	southwest	
Locust, Black	8 ft.	20 ft.	20 ft.	45 ft.	X	X	X		X	X	X	X	X		X	X				X			8-12 in.	3/4 in.	X	X		8-10 in.	1/2 in.	X	X	X	X		X				X	none	
Locust, Water	8 ft.	25 ft.	16 ft.	45 ft.			X	X	X			X				X	X				X		8-14 in.	3/4 in.	X	X		6-8 in.	3/8-1/2 in.				X		X				X	none	
Locust, Honey	15 ft.	25 ft.	30 ft.	50 ft.		X	X	X	X	X		X				X				X			10-14 in.	3/4 in.	X			10-12 in.	1/2 in.	X			X	X					X	none	
Locust, Besson's	18 ft.	25 ft.	...	...		X	X	X	X	X		X				X				X			10-12 in.	1/2 in.	X	X		...	...				X		X				X	southwest	
Magnolia, Cucumber	15 ft.	22 ft.	20 ft.	35 ft.	X	X	X			X		X	X			X				X			8-10 in.	1/2 in.	X			6-8 in.	3/8 in.		X	X	X		X				X	southwest	
Magnolia, Umbrella	20 ft.	20 ft.	...	...			X			X		X				X				X			10-12 in.	3/8 in.			X	6-8 in.	1/4 in.		X	X	X		X				X	southwest	
Magnolia, Sweet Bay	6-20 ft.	15-30 ft.	25 ft.	30 ft.			X	X	X	X		X			X	X	X			X	X		8 in.	1/4 in.			X	6 in.	1/8 in.		X		X	X					X	southwest	
Magnolia, Bull Bay	10 ft.	25 ft.	18 ft.	40 ft.	X	X	X		X	X		X				X	X			X	X		10 in.	1/4 in.			X	8 in.	1/4 in.		X		X		X				X	southwest	
Magnolia, Saucer	18 ft.	20 ft.	30 ft.	28 ft.			X			X		X	X			X	X			X	X		8-12 in.	1/4 in.			X	6-8 in.	1/4 in.		X		X		X				X	southwest	
Maple, Norway	20 ft.	20 ft.	30 ft.	35 ft.	X	X	X			X		X				X				X			6-8 in.	3/8 in.			X	6-8 in.	1/4 in.		X		X		X				X	southwest	
Maple, Little Hedge	10 ft.	15 ft.	...	...			X			X		X				X				X			2-4 in.	1/16 in.			X	2-4 in.	1/16 in.		X		X		X				X	southwest	
Maple, Sugar	10 ft.	25 ft.	20 ft.	50 ft.	X	X	X	X		X	X	X				X				X			6-10 in.	3/8 in.			X	6-10 in.	3/8 in.		X		X		X				X	none	

	Size 20 yrs.		Size 40 yrs.		Use				Soils							Exposure				Permissable Sunshine			Annual growth at 20 yrs. on a fair site			Annual growth at 40 yrs. on a fair site			Type		Strength			Maintenance		Wind protection required from	Remarks
	Spread	Height	Spread	Height	Boulevard	Street	Lawn	Background	Wet	Normal	Dry	Fertile	Not Exacting	Light	Heavy	Maximum	Normal	Minimum	Not Exacting	Maximum	Normal	Minimum	Terminal Branches	Trunk Diameter	Fast	Medium	Slow	Terminal Branches	Trunk Diameter	Fast	Medium	Slow	Upright	Spreading	Easily Broken	Withstands wind & sleet	Very strong	Costly	Normal		
Maple, Black	8 ft.	20 ft.	15 ft.	30 ft.	X	X	X			X		X				X				X			6-8 in.	1/4 in.		X	X	6-8 in.	1/4 in.			X	X			X		X	none	
Maple, Sycamore	15 ft.	22 ft.	20 ft.	30 ft.	X	X	X			X		X					X				X		4-6 in.	1/4 in.		X	X	4-5 in.	1/8 in.			X	X	X				X	southwest	
Maple, Little Amur	6 ft.	12 ft.	8 ft.	20 ft.			X			X		X						X			X		2-4 in.	1/16 in.			X	2-4 in.	1/16 in.			X		X			X		southwest	
Maple, Japanese	8 ft.	10 ft.	12 ft.	15 ft.			X			X		X						X			X	X	2-4 in.	1/16 in.			X	2-4 in.	1/16 in.			X		X				X	all summer wind	
Maple, Red	6 ft.	18 ft.	15 ft.	25 ft.			X		X	X		X				X				X			4-6 in.	1/4 in.		X	X	4-5 in.	1/8 in.		X	X	X				X		X	southwest	
Maple, Swamp Red	8 ft.	18 ft.	20 ft.	25 ft.		X	X	X	X	X		X					X				X		4-8 in.	1/4 in.		X	X	4-6 in.	1/4 in.			X		X				X	southwest	
Maple, Silver	10 ft.	30 ft.	25 ft.	50 ft.	X	X	X	X	X	X		X				X				X			6-12 in.	3/4 in.	X			6-10 in.	1/2 in.	X			X	X				X		X	none	
Maple, Box Elder	15 ft.	20 ft.	30 ft.	30 ft.			X	X	X			X				X				X			8-12 in.	3/4 in.	X			6-8 in.	3/8 in.	X			X	X			X		X	none	
Mulberry, Red	20 ft.	20 ft.	30 ft.	35 ft.			X	X		X		X					X			X			8-14 in.	3/4 in.	X			8-10 in.	1/2 in.	X			X		X		X		X	none	
Oak, White	8 ft.	20 ft.	12 ft.	40 ft.	X	X	X	X		X	X			X	X	X				X			6-8 in.	3/8 in.			X	X	6-8 in.	1/4 in.			X			X			X	none	
Oak, Bur	10 ft.	20 ft.	16 ft.	30 ft.	X	X	X	X	X	X		X					X			X			6-10 in.	3/8 in.			X	X	6-8 in.	1/4 in.			X	X			X		X	none	
Oak, Swamp White	12 ft.	25 ft.	18 ft.	40 ft.	X	X	X	X	X	X		X		X	X			X		X			6-12 in.	3/8 in.			X	X	6-8 in.	1/4 in.			X	X			X		X	none	
Oak, Chinquapin	8 ft.	15 ft.	25 ft.	30 ft.			X	X		X	X		X			X				X			6-8 in.	1/4 in.			X	6-8 in.	1/8 in.			X		X				X	none	
Oak, Post	10 ft.	20 ft.	20 ft.	30 ft.	X	X	X	X		X	X		X			X				X			6-8 in.	1/4 in.			X	6-8 in.	1/8 in.			X	X			X		X	none	
Oak, Northern Red	8 ft.	20 ft.	20 ft.	35 ft.			X	X		X	X	X				X				X			6-8 in.	3/8 in.			X	6-8 in.	1/4 in.		X		X				X		X	none	
Oak, Shumard's	8 ft.	20 ft.	20 ft.	35 ft.	X	X	X		X	X	X	X				X				X			6-8 in.	3/8-1/2 in.	X	X		6-8 in.	1/4 in.		X		X	X			X		X	none	
Oak, Pin	12 ft.	22 ft.	25 ft.	40 ft.	X	X	X	X	X	X		X				X	X			X			6-12 in.	3/8-1/2 in.	X	X		6-10 in.	3/8 in.		X		X				X		X	none	
Oak, Shingle	12 ft.	20 ft.	25 ft.	35 ft.	X	X	X	X	X	X		X					X			X			8-10 in.	3/8 in.			X	6-8 in.	1/4 in.		X			X			X		X	none	
Oak, Willow	10 ft.	18 ft.	12 ft.	25 ft.			X		X	X		X					X			X			6-8 in.	1/4-3/8 in.		X	X	6-8 in.	1/4 in.			X	X	X				X	none	
Oak, Overcup	14 ft.	18 ft.	...	...			X		X	X		X					X			X			8-12 in.	3/8 in.		X	X	8-10 in.	1/4 in.		X	X		X			X		X	none	
Pagoda Tree	16 ft.	25 ft.	28 ft.	30 ft.	X	X	X	X		X	X	X				X				X			6-10 in.	1/4 in.		X		6-8 in.	1/4 in.		X			X		X			X	southwest	
Persimmon	12 ft.	20 ft.	20 ft.	35 ft.		X	X	X		X	X	X				X				X			6-8 in.	1/4 in.		X		6-8 in.	1/4 in.		X		X						X	none	
Plums and Cherries	too variable to be included in this list																																							
Redbud	12 ft.	18 ft.	18 ft.	25 ft.			X	X		X		X					X				X		6-10 in.	1/8-1/4 in.			X	6-8 in.	1/8 in.			X	X	X				X	southwest	
Sassafrass	10 ft.	20 ft.	15 ft.	30 ft.			X	X		X	X		X			X				X			6-10 in.	1/4 in.		X		6-8 in.	1/4 in.		X	X		X				X	none	
Osage Orange	12 ft.	25 ft.	25 ft.	40 ft.	X	X	X	X		X	X	X			X	X				X			8-12 in.	3/8 in.			X	8-10 in.	1/4 in.		X	X			X			X	none	
Serviceberry	8 ft.	18 ft.	12 ft.	25 ft.			X	X		X	X		X				X				X	X	6 in.	1/4 in.			X	4-6 in.	1/8 in.			X	X		X			X	southwest	
Sycamore	12 ft.	35 ft.	18 ft.	50 ft.	X	X	X	X	X	X		X	X		X	X				X			6-12 in.	3/4-1 in.	X			6-10 in.	1/2 in.		X		X				X		X	none	
Tulip Tree	8 ft.	25 ft.	24 ft.	35 ft.	X	X	X	X	X	X		X			X	X				X			6-12 in.	3/4 in.	X			6-10 in.	1/2 in.		X		X				X		X	none	
Walnut, Black	12 ft.	30 ft.	24 ft.	40 ft.	X	X	X		X	X		X		X		X				X			10-14 in.	3/4-1 in.	X			8-10 in.	1/2 in.		X		X	X		X			X	none	
Willows							X	X	X	X		X				X	X			X	X								X											none	
Yellow Wood	6 ft.	15 ft.	20 ft.	25 ft.		X	X	X		X		X				X				X			6-8 in.	1/2 in.			X	6 in.	1/4 in.	X			X	X			X		X	none	
Zelkova	10 ft.	15 ft.	18 ft.	30 ft.			X	X		X	X					X					X		6-8 in.	1/4 in.			X	6-1/2 in.	1/4 in.			X		X				X	southwest	
Pine, White	12 ft.	22 ft.	20 ft.	45 ft.			X	X		X		X		X		X	X				X	X	10-12 in.	3/4 in.	X		X	10 in.	1/2 in.			X	X		X			X	southwest	
Pine, Himalayan	6 ft.	12 ft.	20 ft.	30 ft.			X	X		X		X				X	X				X	X	10 in.	1/2 in.			X	10 in.	1/4 in.			X	X		X			X	southwest	
Pine, Ponderosa	10 ft.	25 ft.	15 ft.	40 ft.			X	X		X	X	X				X				X			12 in.	1/2 in.			X	10 in.	1/4 in.		X		X				X		X	none	
Pine, Black	12 ft.	25 ft.	25 ft.	30 ft.			X	X		X		X				X					X		12 in.	1/2 in.			X	8 in.	1/8 in.			X	X				X		X	southwest	
Pine, Scots	14 ft.	25 ft.	16 ft.	28 ft.			X	X		X		X				X					X		10 in.	1/2 in.			X	6 in.	1/4 in.			X	X				X		X	southwest	
Pine, Jap. Red	18 ft.	20 ft.	...	...			X	X		X			X			X					X		10 in.	1/4 in.			X	...	...			X					X		X	southwest	
Pine, Jap. Black	20 ft.	22 ft.	...	...			X	X		X			X			X					X		12 in.	1/4 in.			X	...	...			X	X				X		X	southwest	
Pine, Jack	12 ft.	25 ft.	...	...			X	X		X						X					X		12 in.	1/4-3/8 in.			X	...	...			X					X		X	southwest	
Pine, Scrub	10 ft.	18 ft.	...	...			X	X		X						X				X			10 in.	1/4 in.			X	...	...			X					X		X	none	
Pine, Short-leaf	8 ft.	20 ft.	...	...				X			X					X				X			12 in.	1/4 in.			X	...	...			X					X		X	southwest	
Spruce, Colorado	8 ft.	18 ft.	...	...			X			X		X						X			X		12 in.	1/8 in.			X	...	...			X					X		X	southwest	
Spruce, White	12 ft.	22 ft.	...	...			X			X		X						X			X		10-14 in.	1/4 in.			X	...	...			X					X		X	southwest	
Spruce, Norway	8 ft.	25 ft.	...	...			X	X		X		X				X				X			10-16 in.	1/4-3/8 in.		X		...	...			X					X		X	southwest	
Spruce, Tigertail	5 ft.	10 ft.	...	...			X			X		X				X				X			6-8 in.	1/8 in.			X	...	...			X					X		X	southwest	
Fir, Colorado	10 ft.	20 ft.	...	...			X			X		X						X			X		6-10 in.	1/8-1/4 in.			X	...	...			X					X		X	southwest	
Fir, Douglas	10 ft.	30 ft.	...	...			X	X	X	X		X						X			X		10-14 in.	1/4-3/8 in.	X			...	...			X		X			X		X	all directions	
Cypress, Bald	12 ft.	40 ft.	14 ft.	60 ft.	X	X	X	X	X	X	X	X				X				X			10-20 in.	3/8-1/2 in.	X			12 in.	3/8 in.	X			X		X			X		X	none	
Holly, American	16 ft.	20 ft.	20 ft.	30 ft.	X		X	X	X	X		X				X				X			6-10 in.	1/4 in.		X		6-8 in.	1/8-1/4 in.		X		X			X			X	southwest	
Cedar, Red	4-20 ft.	25 ft.	8-20 ft.	35 ft.			X	X		X	X		X			X				X			12 in.	1/4 in.	X	X		10 in.	1/8-1/4 in.		X	X	X			X			X	none	

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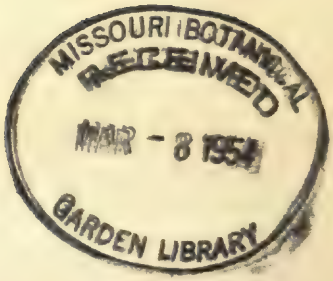
POSSIBLE MAXIMUM VARIATIONS IN THE FORCE OF GRAVITY AS MAY BE OBSERVED AT THE EARTH'S SURFACE

by

V. G. GABRIEL



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POSSIBLE MAXIMUM VARIATIONS IN THE FORCE OF GRAVITY AS MAY BE OBSERVED AT THE EARTH'S SURFACE

by V. G. Gabriel*

Abstract - The earth and its ideal mathematical representation, a spheroid of revolution, are briefly defined in terms of radii and other parameters of the earth. The force of gravity at the earth's surface is defined with the use of Newton's law of universal gravitation and Free-Air Gravity, Bouguer gravity, Isostatic compensation, etc., are briefly explained. The use of gravimetric measurements in scientific research and in exploration for oil and metals are briefly discussed.

With the application of generally accepted formulae, the combined effect of the theoretical gravity values referred to the International Ellipsoid and the maximum gravity deviations due to altitude, the Bouguer, isostatic, and other necessary corrections, are evaluated and plotted as a "Latitude---Possible Maximum Gravity Variation Curve." Some examples for the evaluation of maximum variations are given.

Introduction - The gravity observations made at the surface of the earth with the use of various gravitational devices, such as pendulums, gravimeters, and the Torsion Balance in the past, have played a larger and larger part in the study of the earth, both its crustal and subcrustal layers. In the last three decades however, the use of gravitational methods has been extended to the study of dam sites, railroad and building foundations, and to the search for oil and metals located, figuratively speaking, in the skin of the earth, that is, in the upper layers of the earth's crust.

Gravitational observations are based on the fundamental property of matter to possess a certain mass and on the ability of the various gravitational instruments of responding to this property, or its

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variations. The mass contained in one cubic centimeter is designated as density, ϱ, and dimensionally is equal to gram-mass/cm^3. However, it is to Newton (1643-1727) to whom the world is under great obligations for the discovery of certain natural laws and establishment of certain new sciences. Among the natural laws discovered by Newton are the Law of Gravitation and the statement (Second Newton's Law) that the force is proportional to the rate of change of momentum. Mathematically it can be expressed as:

$$F = \frac{d}{dt}(mv) = m\frac{dv}{dt} = ma$$

$$Fat = \gamma \frac{m_1 m_2}{r^2}$$

where:

F = Force

Fat = Force of attraction

v = Velocity of a moving body

a = Acceleration of a moving body

γ = Constant of gravitation = 66.7×10^{-9} c.g.s.

m_1 = Mass of the first body

m_2 = Mass of the second body

r = Distance between the centers of the m_1 and m_2 masses.

Near the surface of the earth all the physical bodies lacking support will fall toward the earth with a certain acceleration, due to the presence of attraction between the mass of the body and the mass of the

earth. This attraction toward the earth is usually referred to as the force of gravitation and its acceleration is usually designated as g. A body located on the surface of the earth will experience a pull toward the center of the earth. This pull is nothing but the weight of the body. Therefore at the surface of the earth the following equation, based on Newton's laws, can be set:

$$m_1 g_m = \gamma \frac{m_1 M}{R^2} \quad \text{or} \quad g_m = \gamma \frac{M_m}{R_m^2}$$

where:

g_m = 980 cm/sec^2 = 980 gals = Mean acceleration at the earth's surface

$M = 4/2\pi \varrho_m R_m^3$ = Mass of the earth

ϱ_m = 5.52 = Mean density of the earth

R_m = 6367 km = Mean radius of the earth

gal = Acceleration of one gram-mass equal one centimeter per second

The continents of the earth have high mountain chains of large extent and the oceans deep depressions of extent comparable to that of the mountains. For example the highlands of the Himalayas rise to over 29000 feet above sea level at places. In spite of these variations in altitude of the surface of the earth, the earth can be taken, as the first approximation, to be a spheroid of revolution with its polar and equatorial radii equal to 6357 kilometers and 6378 kilometers approximately, respectively. The forces of gravity, with the necessary corrections due to the rotation of the earth, have been computed for this ideal spheroid and are usually given in a table form as "Values of Theoretical Gravities on International Ellipsoid."

The gravity observations taken at the earth's surface will deviate considerably from the gravitational values given in the table and

referred to the points located on the International Ellipsoid directly under the observation points. These deviations will be due to the altitude of an observation point in respect to the altitude of its projection point located on the Ellipsoid, the topography and the type, that is, the density of rocks present near the point of observation, and on the magnitude of the isostatic compensation. It is assumed in the commercial and semi-rigorous scientific surveys, that in correction for altitude one meter in height corresponds to the change in acceleration of gravity equal to ± 0.3086 milligals, where one milligal is equal to 1/1000 of a gal. The observed gravity corrected on altitude is called Free-Air Gravity, and the difference between the Free-Air Gravity value at the point of observation and the value of gravity at its projection point located on the Ellipsoid is referred to as Free-Air correction. Similarly Free-Air Gravity corrected on the average density and topography of rocks located between the altitudes passing through the point of observation and its projection on the Ellipsoid, or sea level, is referred to as Bouguer gravity. The difference between the Bouguer gravity of an observation point and the gravity of its projection point located on the Ellipsoid is referred to as Bouguer anomaly. The Bouguer gravity corrected for certain assumptions based on the Theory of Isostasy, minus the value of gravity at the projection point located on the Ellipsoid, is referred to as isostatic anomaly. In general, it is assumed that isostatic anomaly, neglecting the errors in computation and assumptions, is due to the incomplete compensation of the blocks of the earth's crust floating in a heavier, semi-plastic substratum. According to Airy, an English scientist of the middle of the 19th century, the blocks of the earth are floating as icebergs in the ocean: the higher the average altitude, the greater the submergence (Mountain Roots' Theory).

In this article, for the convenience of plotting and understanding, Free-Air Gravity and Bouguer Gravity are assumed to be the values of gravity before the gravity corrections are applied for altitudes and density layers respectively in variance with the common usage.

Gravitational methods are used for both scientific and utilitarian purposes.

Scientific investigations lead to our better understanding of the shape of the earth, the geoid surface, i.e., a sea level surface, the

distribution of rocks in the earth's crust, the existence and magnitude of isostasy and other scientific phenomena. In survey prospecting for oil and metals the gravitational methods indicate the presence of structures favorable to oil accumulation (anticlines, faults, etc.) and the presence of metalic deposits, basement rocks, etc., and favorable geological factors. In civil engineering, it is used more and more in the studies of foundation for dam sites, railroads, various heavy structures. It is probable that a biologist, paleontologist, and anthropologist might find of some interest to study the maximum variations in the force of gravity due to changes in altitude, topography, etc., and their influences on the survival of certain species.

In prospecting for local gravitational anomalies, it is a common practice to apply latitude, free air, Bouguer, terrain, regional, and daily variation corrections to the observed gravitational values. In regional surveys, isostatic corrections should be taken into consideration.

The Study of Possible Maximum Variations - To obtain the maximum possible variations of the force of gravity at the earth's surface, we must reverse the procedure which is usually used in gravitational prospecting and add or subtract to the gravity values referred to the "Normal Spheroid" (the "International Ellipsoid"), the necessary corrections. These corrections are: free air, Bouguer, terrain, daily variations, regional, isostatic, and local anomaly. To expedite the computations, we can safely assume that the sum of daily variations, regional, isostatic corrections plus a local anomaly cannot exceed, in the great majority of cases, $\pm$ 300 milligals. Terrain corrections should also be neglected because in many poorly dissected territories, their contribution to the observed gravity may be negligible. Bouguer corrections for the points located above sea level were also neglected because in the well dissected territories the application of the Bouguer corrections may introduce considerable error. In evaluating the maximum variations, the following assumptions have been made:

Density of basement rocks under the oceans = 3.0
Average density of sea water = 1.00
Change in gravity per 1 meter of height at any latitude
= 0.3086 mgals.
Bouguer correction = 0.04186ϱ mgals. per meter where:
ϱ = Density

The computation of the possible maximum deviation of the force of gravity at the surface of the earth are given in Table I and Table II. The results so obtained have been plotted in Figure 1 as "Possible Maximum Gravity Versus Latitude Curve."

Figure 1 gives the Free-Air Gravity, the Bouguer Gravity, and the Possible Minimum and Maximum Gravity Curves. The Free-Air Gravity Curves, computed for +5,000 and +10,000 meter altitudes, represent the values of gravity at various latitudes referred to the Normal Spheroid minus free air corrections. The Bouguer Gravity Curves, computed for -5,000 meter and -10,000 meter oceanic depths, represent the values of gravity at various latitudes referred to the Normal Spheroid plus free air minus Bouguer corrections. The minimum Gravity Curve represents the sum of the Free Air Gravity minus 0.3 gals., the value which was assumed to represent the maximum possible deviation for regional, isostatic and daily variation corrections. The Maximum Gravity Curve represents the sum of the Bouguer Gravity plus 0.3 of a gal.

The study of Figure 1 shows that for the land located at altitudes above sea level the maximum possible variation in the force of gravity cannot exceed 8.56 gals., that is 983.22 gals. minus 974.66 gals., where 983.22 is the value of gravity at the pole at sea level and 974.66 is the value of gravity at the equator at +10,000 meter altitude.

Examples - Assume that an area is located at 75 degrees latitude with the mean altitude equal to 4,000 meters. According to Figure 1 its Free Air Gravity will be equal to 981.80 gals., approximately, and the possible Maximum Gravity will be (981.80 + 0.3) gals., or 982.10 gals., approximately.

An area located in the Himalaya Mountains, and whose latitude is 25 degrees and the mean altitude is equal to 7,500 meters, will have the Free-Air Gravity in the area equal to 976.65 gals., and the possible Minimum Gravity equal to (976.65 - 0.3) gals., or 976.35 gals., approximately.

The author would like to express his thanks to Dr. A.C. Sprang of the Geology Department, Missouri School of Mines and Metallurgy, U. of Missouri, Rolla, Mo., for his helpful suggestions.

TABLE II

APPROXIMATE GRAVITY IN GALS.	LATITUDE in degrees									
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Gravity on Norm. Spheroid*. . . .	978.05	978.20	978.65	979.34	980.18	981.08	981.92	982.61	983.06	983.22
Free Air Corr. at -5,000 m.d. . .	+1.54	+1.54	+1.54	+1.54	+1.54	+1.54	+1.54	+1.54	+1.54	+1.54
Bouguer Corr. at -5,000 m.d.. . .	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21
Bouguer Gravity at -5,000 met. depth.	979.38	979.53	979.98	980.67	981.52	982.41	983.25	983.94	984.39	984.55
Free Air Corr. at -10,000 m.d.. .	+3.09	+3.09	+3.09	+3.09	+3.09	+3.09	+3.09	+3.09	+3.09	+3.09
Bouguer Corr. at -10,000 m.d. . .	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42
Bouguer Gravity at -10,000 met. depth.	980.72	980.87	981.32	982.01	982.85	983.75	984.59	985.28	985.73	985.89
Max. Regional, Isostatic and Local Anomaly.	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
Maximum Possible Grav..	981.02	981.17	981.62	982.31	983.15	984.05	984.89	985.58	986.03	986.19

Assumed: Density of Basement Rocks under Oceans = 3.00
Density of Water = 1.0
Bouguer Correction = 0.04185 ph. mgals.

Where: ϱ = Density
h = Depth in meters
* After Nettleton

TABLE I

APPROXIMATE GRAVITY IN GALS.	LATITUDE in degrees									
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Gravity on Normal Spheroid* . . .	978.05	978.20	978.65	979.34	980.18	981.08	981.92	982.61	983.06	983.22
Free Air Corr. at +5,000 met. . .	-1.54	-1.54	-1.54	-1.54	-1.54	-1.54	-1.54	-1.54	-1.54	-1.54
Free Air Grav. at +5,000 met. Altitude	976.51	976.66	977.11	977.80	978.64	979.54	980.38	981.07	981.52	981.68
Free Air Corr. at +10,000 met.. .	-3.09	-3.09	-3.09	-3.09	-3.09	-3.09	-3.09	-3.09	-3.09	-3.09
Free Air Grav. at +10,000 met. Altitude	974.96	975.11	975.56	976.25	977.09	977.99	978.83	979.52	979.97	980.12
Max. Regional, Isostatic and Local Anomaly.	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
Minimum Possible Gravity.	974.66	974.81	975.26	975.95	976.79	977.69	978.53	979.22	979.67	979.82

* L. L. Nettleton, "Geographical Prospecting for Oil" p. 140
Assumed: Free Air Correction for all Latitudes = 0.3086 mgals. per meter

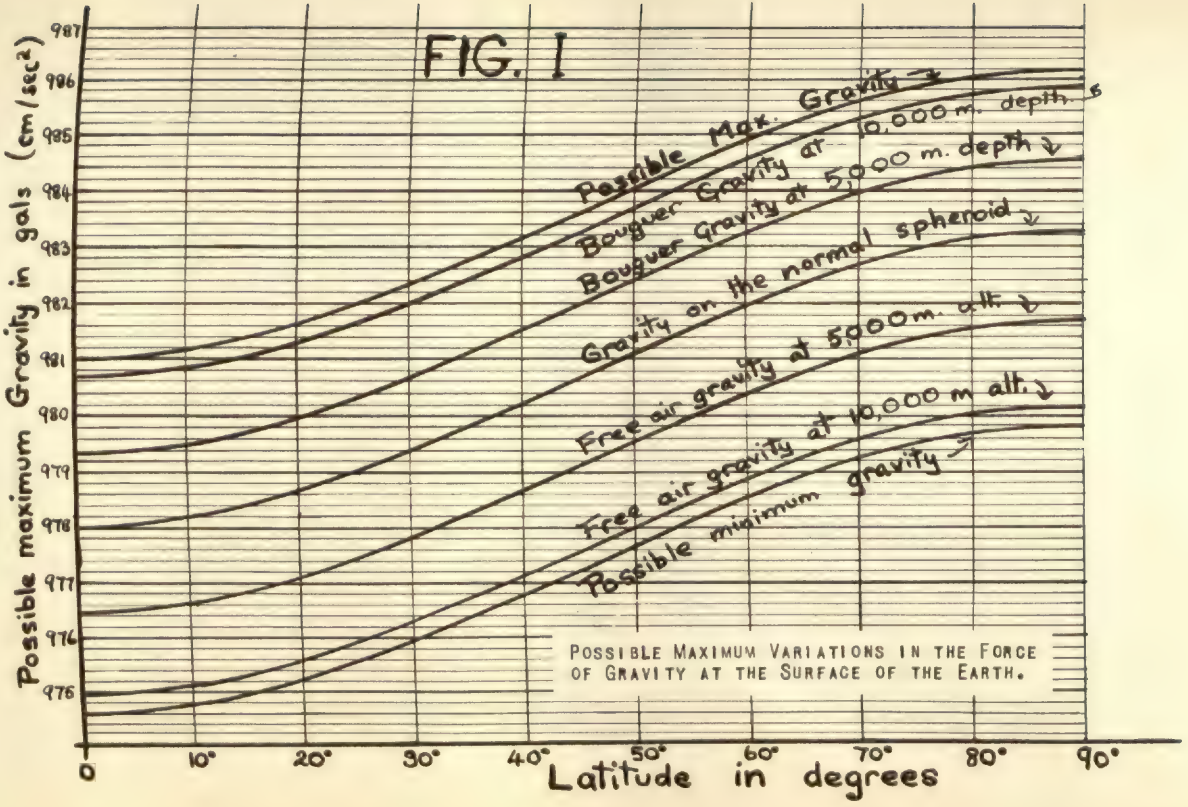
FIG. I
Possible maximum Gravity in gals (cm/sec²)
987
986
985
984
983
982
981
980
979
978
977
976
975
Possible Max. Gravity
Bouguer Gravity at 10,000 m. depth
Bouguer Gravity at 5,000 m. depth
Gravity on the normal spheroid
Free air gravity at 5000m. alt.
Free air gravity at 10,000 m alt.
Possible minimum gravity
POSSIBLE MAXIMUM VARIATIONS IN THE FORCE OF GRAVITY AT THE SURFACE OF THE EARTH.
0
10°
20°
30°
40°
50°
60°
70°
80°
90°
Latitude in degrees

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BOTANIC

A CENTENNIAL HISTORY

of the

Academy of Science of St. Louis

Compiled by

Edwin P. Meiners, M. D.

ST. LOUIS, MISSOURI
1956

The Museum of Natural History, Science and Industry
of the
Academy of Science of St. Louis
4642 Lindell Boulevard

BOTANIC

"The struggle of the democracies against the dictatorships is not only a fight for freedom to live, a fight to satisfy physical and emotional hunger, but it is just as importantly at present and even more importantly for the future, a fight for the freedom to think.

"In this struggle the Museum stands at the forefront of the institutions designed to satisfy intellectual hunger. The Museum is not limited like the public school to the young. The Museum is not dedicated like the college or university solely to the educated. The Museum does not like the library, serve only the literate. The Museum deals with all peoples on all levels and can reach out to meet the intellectual hunger of all people of every degree on all levels of intellectual attainment. It is democracy's most important agency for the spread of honest understanding of life."

Reprinted from the 76th annual report of the president, to the Trustees of The American Museum of Natural History, and to The Municipal Authorities of the City of New York, New York.

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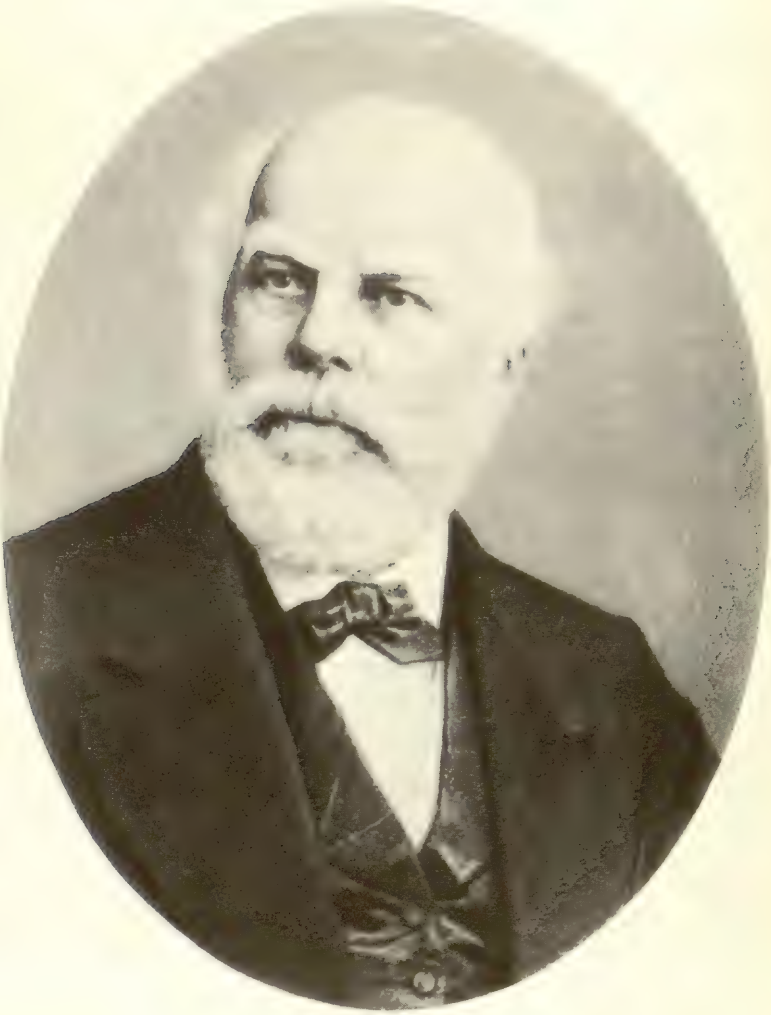
WESTERN ACADEMY OF NATURAL SCIENCES, PREDECESSOR OF THE PRESENT ACADEMY.

In 1837, when St. Louis was scarcely more than a small frontier town, there was organized, through the efforts of two young men of foreign birth, the first society for scientific research established west of the Allegheny Mountains. This new society was called the Western Academy of Natural Science and the main promoters were Drs. George Engelmann and Frederick Adolphus Wislizenus, both destined to play important roles in the future Academy of Science of St. Louis. A charter was granted to H. King, George Engelmann, B. B. Brown, P. A. Pulte, William Weber, Theodore Engelmann, and G. Schuetze as incorporators.

Through the efforts of these men the lamp of science was kept burning for some years. A museum was started and a library of about one hundred volumes was gathered. Five or six acres of ground was purchased, far out of the city of that time, near 8th and Chouteau Aves., where Dr. Engelmann began a Botanical Garden and Arboretum on a small scale. This garden was kept up, after a fashion, for some years, when the society faded out and the land was sold. Just how many years the Academy was active is not known. On April 17, 1843, however, the society elected to honorary membership John James Audubon. The diploma was signed by George Engelmann, president; B. B. Brown, vice-president; William R. Singleton, corresponding secretary; and L. M. Sell, recording secretary.

The Founding of the Academy of Science of St. Louis.

Informal meetings of the local scientists were no doubt continued to be held and the slumbering Academy discussed. Engelmann, however, was not the kind of a man to work indefinitely without closer association with the few other St. Louis men interested in science than was afforded by chance, and on March 10, 1856, after several preliminary meetings, the existing Academy of Science of St. Louis was organized. Those in attendance at the organization meeting were Dr. Engelmann, who acted as chairman, Charles P. Chouteau,



Dr. George Engelmann

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James B. Eads, Nathaniel Holmes, Moses L. Linton, William M. McPheeters, Moses M. Pallen, Simon Pollak, Charles A. Pope, Hiram A. Prout, Benjamin F. Shumard, Charles W. Stevens, William H. Tingley, John H. Watters and Adolphus Wislizenus.

A constitution and by-laws having been adopted, steps were promptly taken for securing a charter or act of incorporation from the legislature, which was granted on the 17th of January, 1857. It is interesting to note that, among other things, this charter provides that under the name of the Academy of Science of St. Louis the incorporators and their associates and successors shall have perpetual succession, may acquire real, personal or mixed property for the advancement of science and the establishment in St. Louis of a museum and library for the study of its various branches; that they may have a common seal, and may make and alter such constitution and by-laws as may be requisite for their government. Exemption from taxation is provided for all property owned or held by the academy so long as it is held and used in good faith for the designated objects. This latter provision is still considered one of the most valuable assets of the Academy at the present time.

Dr. George Engelmann was elected the first president of the newly organized Academy. The other members of the first Council were as follows: Dr. Hiram A. Prout, 1st Vice President; Nathaniel Holmes, 2nd Vice President; Dr. Wm. H. Tingley, Secretary; James B. Eads, Treasurer; Dr. M. M. Pallen, Dr. Wislizenus, Dr. Shumard and C. W. Stevens, Curators.

DR. GEORGE ENGELMANN

Dr. George Engelmann, who undoubtedly was the prime instigator for the promotion of an Academy of Science, as well as a Botanical Garden in St. Louis, was born in Frankfort-on-the-Main, Germany, on February 2, 1809. He attended Heidelberg University for a time where he met Louis Agassiz and other young budding naturalists. He later removed to the University of Wurzberg where he obtained his M.D. degree in 1831. In 1832 he sailed for America and lived for a time with an uncle near Belleville, Illinois. In the fall of 1835 Engelmann settled down in St. Louis and commenced his practice of medicine. During this period he occupied his leisure hours in scientific researches.

In 1835 Engelmann began a remarkable series of meteorological investigations and records were kept up continuously for nearly fifty years. As most of these records were made before the U. S.

Dr. F. A. Wislizenus

N BOTANIC

Weather Bureau was established they have become very valuable in present day meteorological work. In 1848 he prepared the report upon the Cactaceae of Doniphan's Rio Grande and Mexican trip, and later the important reports upon the Cacti of the Pacific Railroad and the Mexican boundary surveys. The bulk of his botanical reports is scattered through the pages of the *Transactions of the Academy of Science of St. Louis*, papers that rank among the best in American botany.

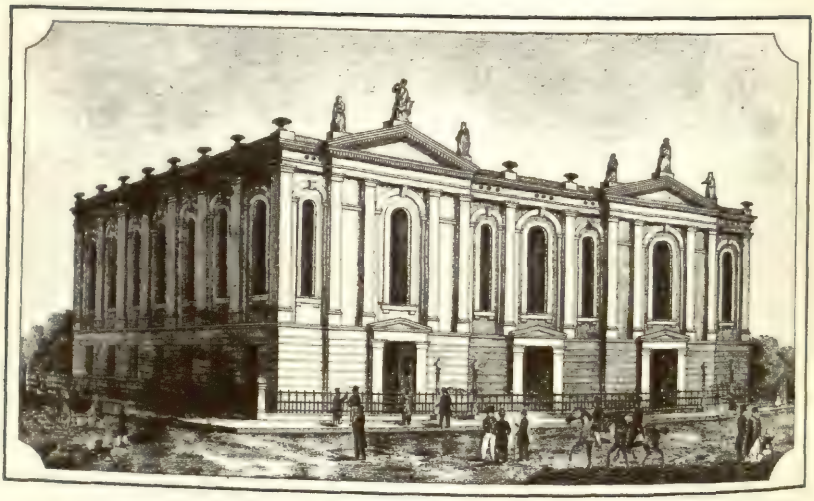
Engelmann was a close friend of Henry Shaw and when the latter began the development of his garden he was able to direct Shaw's taste into profitable channels; the result was that Shaw's Garden is really a botanical garden. From it has grown an institution of the greatest importance and interest—the Missouri Botanical Garden. Here are lodged Engelmann's herbarium, containing rich series of important type specimens. The Garden also possesses all of his original notes and papers. Engelmann died in St. Louis, February 4, 1884.

DR. F. A. WISLIZENUS

Closely associated with Engelmann in all of his interests in the Academy of Science, as well as in the practice of medicine and his interests in botany and meteorology, was Dr. Frederick Adolphus Wislizenus. Dr. Wislizenus was born in 1810 in Koenigsee, in Schwarzburg – Rudolstadt, one of the numerous tiny German principalities of that period. He studied medicine at the University of Jena in 1828 and later at Gottingen and Wurzburg and eventually obtained his M.D. degree in Zurich in 1834. Immediately following he sailed for New York and in 1839 came to St. Louis. Taking advantage of an opportunity to accompany an expedition of the St. Louis Fur Company he went far into the Northwestern country towards the source of the Green river in the Wind River mountains. Later he crossed the Rocky Mountains to Utah and, finding no guide to take him to California, he returned to St. Louis.

Wislizenus was interested in meteorology, botany and mineralogy to which subjects he contributed many original observations. In 1840 he wrote a book on his travels entitled, *Ein Ausflug nach dem Felsen-Gebirge in Jahre 1839*, a rarity among books today. This was translated into English and published by the Missouri Historical Society in 1912 as *A Journey to the Rocky Mountains in the Year 1839*. The United States Government published his *Memoir of a Tour to Northern Mexico in 1846 and 1847* in 1848.

Dr. Wislizenus died in St. Louis, September 22, 1889.



St. Louis Medical College 1853 to 1869 (N.E. Cor. Myrtle & 7th)
Fire destroyed east wing in 1869.

IN BOTANIC

THE FIRST MUSEUM AND LIBRARY

In the Act of Incorporation of the Academy of Science of St. Louis it is stated that its purpose was the advancement of science and the establishment of a museum and library for the illustration and study of its various branches. The first several meetings of the Academy were held in the Hall of the Board of Public Schools. At the second meeting the generous offer of Dr. Charles A. Pope for space in the dispensary building of the St. Louis Medical College was accepted, and here were established the first museum and library of the Academy.

The museum showed encouraging growth immediately. The library and collections of the Western Academy of Natural Science were transferred to the new Academy. Other material was acquired from many sources. Charles P. Chouteau donated numerous mounted and preserved specimens of mammals, birds, reptiles and fish collected on the Upper Missouri river in the course of his fur trade. During the Civil War, when the Federal troops confiscated McDowell Medical College, the Western Sanitary Commission deposited with the Academy what remained of the natural history collections of that institution. Many palaeontological collections were added including an extensive collection of fossils collected by F. V. Hayden in the Bad Lands of Nebraska. Minerals of various kinds, including a collection of meteorites, skulls, skins of mammals and birds, specimens of plants, models of fungi, marine and fresh water shells, insects injurious to vegetation, etc. were among the choice possessions of the museum.

The growth of the museum was quite rapid and it soon became evident that larger quarters had to be obtained. While a special committee was negotiating for securing rooms in the Polytechnic Building, fire broke out in May, 1869, destroying the entire collection. Only the library escaped. Thus ended the first natural history museum in St. Louis.

THE SECOND MUSEUM

No further effort to establish a museum was made by the Academy for some years following the disastrous fire in 1869. During this period the Academy held meetings in the Public School Library Building, Washington University and the Missouri Historical Society. Most of its efforts were confined to holding meetings and the publication of its *Transactions*. Small accessions were acquired from time to time which were boxed up and stored away. In 1876 and 1877 the Archaeological Section of the Academy made extensive excavations

Academy of Science
3817 Olive Street

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in the mounds of southeastern Missouri, in northern Arkansas and in Illinois and considerable pottery and crania were obtained. In 1900 the Academy purchased the Yandell collection of palaeontological specimens rich in crinoids of the Devonian Age, containing many original type specimens. In 1901 Mrs. William L. Bouton donated a collection of 635 butterflies, mostly tropical, preserved in Denton mounts.

Efforts were again made to acquire some kind of a building to house its collections. In 1903 the Academy acquired as a gift from Mrs. William McMillan and her son, William Northrop McMillan, a building located at 3817 Olive street. This building had been originally built for Phillips School, a private school, and seemed adequately adapted to its needs. Now for the first time of its nearly fifty years of existence the Academy owned its own home and specimens and books were again brought out of storage and housed in the new building. The Academy was now in its heyday, the future never appeared more promising and in 1906 celebrated its 50th anniversary with a banquet and much speech making. A bronze medal, featuring the portrait of Dr. Engelmann on the obverse and its seal on the reverse was distributed to all the guests present.

The Academy thus continued to enjoy its own home and museum for a number of years. With the advent of World War I interest again lagged and, in 1917, the Academy was forced, for lack of funds, to again store its collections and close the doors of its building. The library, which had now grown to about 50,000 volumes, was deposited with the St. Louis Public Library for safekeeping. Again the Academy settled down to holding meetings, usually in Washington University and the publication of its *Transactions*.

AN INTERVAL OF EVENTS

However, enthusiasm for a natural history museum would not be stilled. In 1917 a group of naturalists and other interested persons organized The St. Louis Natural History Museum Association. Public lectures, a bulletin and newspaper publicity was used to stir up public interest. This organization functioned for about five years until, in 1922, it turned its assets and good will over to the Academy to continue the cause. Interest, however, again lagged and nothing further was done.

In 1930 another organization, The Greater St. Louis Museum of Natural History, was formed and again the public was appealed to by means of lectures and news items. Financial support, however, was not forthcoming, and in 1934 this organization also turned to the Academy to continue the work. Now the Council of the Academy

authorized and appointed a Museum Committee as one of its standing committees to find ways and means to found a natural history museum in St. Louis.

In 1939 the Academy, cooperating with the Works Progress Administration and the Missouri Resources Museum sponsored an archaeological field exploration of mounds and Indian sites in Jefferson County under the direction of Robert McC. Adams. The material unearthed by this expedition was divided among the Smithsonian Institute, the Missouri Resources Museum and the Academy of Science of St. Louis. That which was allotted to the Academy is on display at the present time in the museum.

In 1939 the St. Louis Museum of Science and Industry also joined forces with the Academy so that applied science, along with natural history, would also find a place in a proposed Science Museum.

THE LECTURE PROGRAM

In the early days of the Academy of Science of St. Louis, members of the society met together frequently and regularly for professional and intellectual companionship. At such meetings there would generally be a carefully prepared lecture by one of the members or by a visitor on a scientific subject, followed by a discussion period and, at the last, a serving of refreshments. Such meetings served as stimuli for research on the part of the various members. Every member was urged to produce. Members disciplined themselves to critical listening to technical presentations on the various scientific subjects presented. In those days science was not so complicated but that astronomers, engineers, medical men, biologists, chemists, geologists, and the like could meet together and find common grounds for intellectual companionship and scientific discussions.

With the coming of rapid extensions in each of the separate fields of science and the great increase in the numbers of scientific workers, as well as the intense specialization required of investigators in each field, common ground rapidly decreased. The time arrived when in meetings between workers from the separate scientific fields there was little of common understanding that could be discussed technically. In the various fields of scientific specialization new societies came into existence such, for example, as the American Chemical Society, the Botanical Society of America, the American Society of Zoologists, as well as various engineering, archeological, and astronomical societies. Each of these societies obtained the full allegiance and devotion of all its members. No longer could the Academy of Science of St. Louis serve as a common meeting ground for workers in all of the various scientific fields.

As a consequence of this the lecture program of the Academy gradually moved in the direction of providing each year a series of semipopular and semitechnical presentations of scientific lectures and demonstrations for the public in general. It was envisioned that such a program might serve several purposes:

> It would provide opportunity for many persons with intellectual and scientific interest to keep abreast of modern scientific developments.
>
> It would furnish opportunity for investigators to keep the public informed about developments in their fields of interest, for without public understanding and public support, science suffers.
>
> It would offer opportunity for the public to see, meet, and hear eminent scientists, thus rescuing scientists from a cloistered existence as well as building enthusiasm for scientific advancement in our community.
>
> It would give each scientist the opportunity to hear semitechnical lectures in scientific fields in which he is only partially specialized, for he, like the rest of us, requires simple explanations when outside the field of his intense specialization.

Unfortunately, a program of lectures, to accomplish the above, and to attract audiences, must deal with subjects of popular interest. This leads to the neglect of fields that are of great scientific significance but of less popular appeal.

The competition of radio and television has added to the difficulty of attracting large audiences. Likewise, parking difficulties and the unavailability of meeting places have become added obstacles.

In spite of all these complications the officers of the Academy have been dogged in their persistence in working for a successful program of scientific lectures for the good of scientific advancement in the community. There is the conviction that there are many St. Louisans interested in this sort of thing who would enjoy habituating themselves to regular attendance at scientific lectures, if we can only succeed in contacting and enlisting them in this activity of our organization.

CHARLES H. PHILPOTT

THE LIBRARY AND PUBLICATIONS

The library of the Academy of Science of St. Louis was organized soon after the founding of the Academy in 1856. By the turn of

the century it was said to be the most extensive of its kind west of the Alleghenies. The library consists of approximately seventy thousand volumes and is increasing at the rate of about a thousand volumes a year. Preserved here are the journals and reports of scientific organizations, learned societies and universities from all parts of the world covering a period of many years. Here are the original contributions of scientific workers in many fields. It should be stressed that, not only are the older publications found here, but the latest scientific literature is being received daily. The fact that some of the material is very rare and not available elsewhere in the west especially emphasizes the importance of the libary. Publications in all branches of both pure and applied sciences are represented. One may find the significant literature of the early years of development in many fields and thus the library is invaluable to investigators who desire to go into the early work on their subject. Its value to commercial and industrial concerns of the community is evident.

After our building on Olive Street became inadequate the library was shelved in the St. Louis Public Library and later in the Washington University Library. These institutions were unable to continue housing the large Academy of Science Library because of their demands for space. In the near future it will be available in the new library building of St. Louis University.

The library has been built and maintained by the exchange of the *Transactions of the Academy of Science of St. Louis* for the publications of other institutions and learned societies. Many do not realize the important status of these publications of the Academy. Up to recent years no academy of science in this country could present a more creditable record of publication. Three hundred and ninety-seven scientific treatises have been published, many of them of considerable importance even today. There are original descriptions of the geology, flora and fauna of the west. There are translations of Egyptian papyrus scrolls and American Indian legends. There are papers ranging from astronomy, meteorology, mathematics and physics to archaeology and ethnology. The continued sale of many of these publications is an indication of their importance. The Academy has been negligent about keeping up with this fine tradition. It is still a duty of the Academy to publish articles which do not have a place in the journals of the specialists. This is especially true of items of local importance.

H. A. Bulger

THE PRESENT MUSEUM

The present building, located at 4642 Lindell Blvd., housing the museum and offices of the Academy, was acquired in 1944 as a gift from Joseph Desloge. The museum was opened on March 21, 1945 with a temporary loan exhibit of a collection of model water craft belonging to Harold C. Stiers. A new museum committee was appointed by the Council to plan and develop the museum along the lines of natural history and applied science. The following were appointed Curators to develop their respective departments: Dr. H. A. Bulger, anthropology and archaeology; Dr. E. P. Meiners, invertebrates; Carl Miller, geology and palaeontology; John J. O'Fallon, aeronautics; and Max Schwarz, birds and mammals.

Specimens were now brought out of storage and natural history exhibits were prepared to replace the temporary exhibit of boats. Several valuable collections have been acquired either by gift or purchase. In 1947 Mrs. Henry M. Whelpley donated the Whelpley collection of Indian artifacts, variously estimated to be worth about $75,000. A valuable collection of marine shells was presented by Joseph Desloge. William G. Drosten gave the Academy a collection of replicas of the famous diamonds of the world. In 1948 "Miss Jim", a famous elephant of the St. Louis Zoo, died and the skull was presented to the Academy. In 1953 the Academy purchased an extensive collection of gems and gem stones formed by Father Prokes of St. John Nepomuk parish. Three collections of butterflies and moths formed by entomologists of a generation ago have been added to the Academy's collection. These are the Hermann Schwarz, Fred Schwarz and George Hosenfelt collections.

In 1946 the Academy appointed Dr. Donald C. Lowrie as full time director. Dr. Lowrie had formerly been a curator in the museum of the Chicago Academy of Science. Dr. Lowrie resigned in 1947 and Richard C. Froeschner was appointed to take his place. Mr. Froeschner resigned in 1948. Since then the museum has been without a director, the scientific work being entirely under the supervision of the Board of Curators which now form the Museum Committee.

Some of the more important exhibits in the museum at the present time are: a collection of mounted birds collected in this area by Julius Hurter more than fifty years ago; the Drosten and Prokes gem collection; some of the choice items from the Whelpley collection arranged by Mr. Froeschner to illustrate the life of the American Indian; a collection of Indian textiles loaned by Dr. H. A. Bulger; a collection illustrating the story of insect life arranged by

Dr. E. P. Meiners; a collection of sea shells and other marine life; the geological and palaeontological collections arranged by Carl Miller; and a very complete collection of models of aeroplanes illustrating the development of aeronautics, arranged by John J. O'Fallon.

In 1954 the Mahlon B. Wallace, Jr. family presented to the Academy a very fine habitat group showing a group of animals at a water hole in Africa. As this habitat group was too large to exhibit it effectively in the cramped quarters of the present museum other quarters had to be sought. This was eventually obtained by arrangements with the City of St. Louis to use a portion of the old World's Fair Pavilion in Forest Park where it may now be seen.

In 1950 the Academy adopted a revised Constitution and By-laws which provided for a change in the administrative body from the old Council, consisting of twelve members, to a Board of Directors, consisting of twenty-five members each serving five years in consecutive groups of five. In 1956 the Academy elected Mrs. Elmer C. McCaddon to the Board of Directors, the first woman to serve on the administrative body in more than fifty years. At the January meeting the Board authorized Mrs. McCaddon to organize The Women's Division of the Academy of Science which she has very ably fulfilled and which gives promise of greatly increased interest and enthusiasm in the Academy.

LOOKING TO THE FUTURE

It is often said, "The first hundred years is the hardest." This year being the one hundredth anniversary of The Academy of Science in St. Louis, we are grateful to say that our museum and the motivating forces behind it have survived this first hundred years. Mere survival thus far is an emblem of victory to the public-minded individuals who, through the years, have fought off the threats of lack of funds and general public indifference to the educational potentialities of the Academy and its further development. If any reward is to be found for the effort of these several generations of members, it will be in the continued hope that the interest of our citizens may be aroused to the importance of building a truly representative museum which could be an integral part of a Science Center.

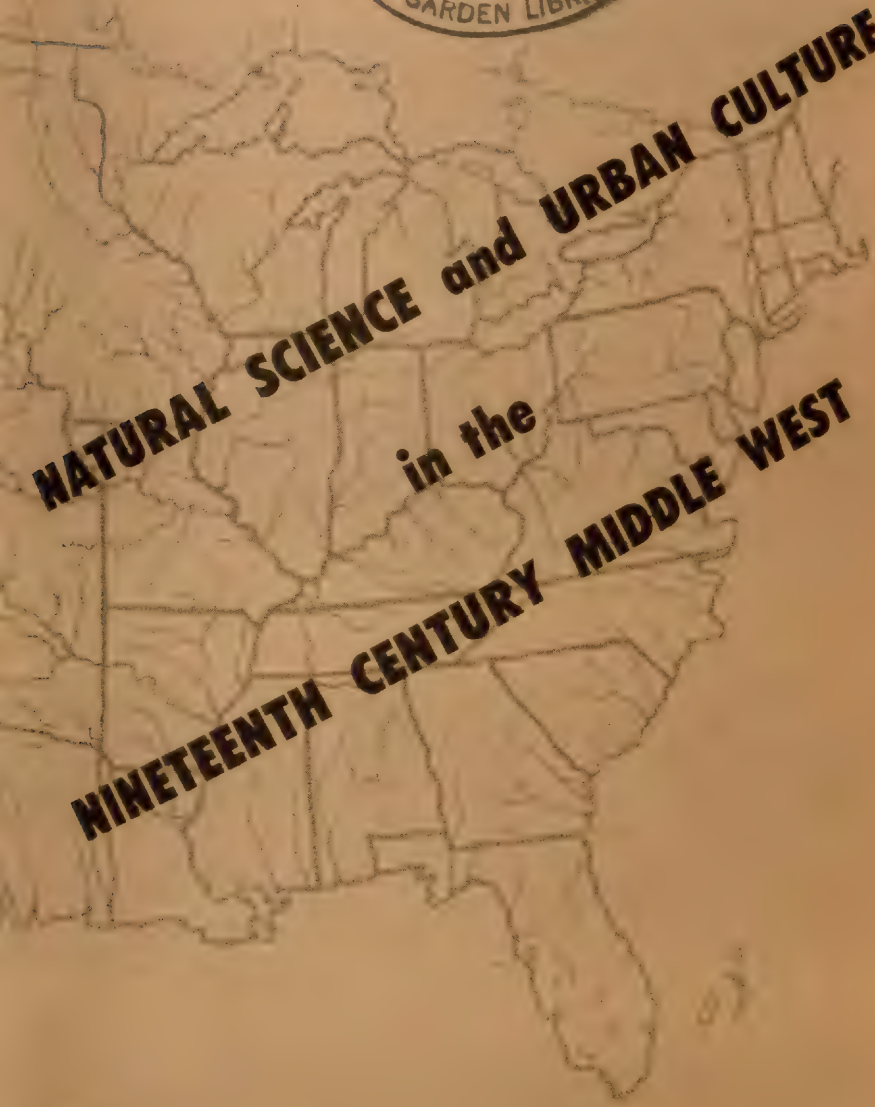
We of the St. Louis area should feel just a bit embarrassed that a city of our size has neither a suitable natural history and science museum nor a planetarium to attract not only the people of our own community but our visitors from out of town. We are missing much in the educational advantages for our children which a well-

equipped and suitable science center could offer, and we are putting ourselves at considerable, needless disadvantage in our rating with other cities.

The approval in the last bond issue of a planetarium is an indication of growing interest in things natural and scientific. It is our sincere hope that not another hundred years, nor fifty, nor ten, will go by without the manifestation of a fitting natural history and science museum, as well as a planetarium, for this great city. It should be part of the plan of "Forward, St. Louis!"

STRATFORD LEE MORTON

MISSOURI BOTANICAL GARDEN
RECEIVED
AUG 13 1959
GARDEN LIBRARY



NATURAL SCIENCE and URBAN CULTURE in the NINETEENTH CENTURY MIDDLE WEST

TRANSACTIONS OF THE
ACADEMY OF SCIENCE
OF SAINT LOUIS

VOLUME 31 JUL 1958 NUMBER 9

NATURAL SCIENCE and URBAN CULTURE in the NINETEENTH CENTURY MIDDLE WEST

WALTER B. HENDRICKSON,
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TRANSACTIONS OF THE
ACADEMY OF SCIENCE
OF SAINT LOUIS

VOLUME 31 NUMBER 9

The Academy of Science of St. Louis was founded in 1856 and chartered by the Nineteenth General Assembly of the State of Missouri by an act dated January 17, 1857. The objects for which the Academy of Science was founded are set forth in the Charter. They are threefold: first, the advancement of science; second, the establishment in the City of St. Louis of a museum for the illustration and study of the various branches of science; third, the creation of a scientific library. Membership in the Academy is not limited to those actively engaged as scientific workers; those interested in science are equally welcome.

NATURAL SCIENCE AND URBAN CULTURE IN THE NINETEENTH CENTURY MIDDLE WEST

by
Walter B. Hendrickson, Professor of History
MacMurray College, Jacksonville, Illinois

Many American traits come from the pioneer past and are closely associated with the farm and the rural way of life, but many others of equal importance come from the city. In fact, since 1900, the city has outstripped the country in influence on our national life. More people live and work in cities than in the country, and even the way of life of those who live and work in the country is largely determined by the city.

But the rise of cities and their influence in the western world is not a phenomenon of the twentieth century. From at least the time of the Renaissance--some historians say from the time of the Crusades--cities have played the leading part in the development of learning, the arts, and the sciences, because where people live close together it is easier to stimulate voluntary group action. With some important exceptions like the Smithsonian Institution, practically all scientific work before the middle of the nineteenth century, in both Europe and America, was sponsored by, or assisted by privately organized academies of science or natural history societies.

It is generally accepted that the earliest scientific organization was the Academia Secretorum Naturae founded in Naples in 1560. Many others were established in Europe in the seventeenth and eighteenth centuries, and all of them had their headquarters in cities. The Royal Society of London, for example, while it had members throughout the British Empire, and acted as a clearing house for scientific information from the British Isles and the possessions beyond the seas, its active membership was largely made up of men who resided and worked in London.

In the eighteenth century, not only were academies founded in the capitals of London, Paris, Berlin and St. Petersburg, but also in such lesser cities as Edinburgh, Dublin, Brussels, Bordeaux, Orleans, Prague, Munich, Göttingen, Frankfort am Main, and Danzig.[1]

The immediate English ancestor of American scientific societies was the Royal Society, founded in London in 1662.[2]

In the American colonies the first was probably the Boston Philosophical Society (1683), with Increase and Cotton Mather as leading members. Cotton Mather was also one of several Americans who were elected to membership in the Royal Society.[3] Because the Mathers and their associates became involved in political and theological disputes, to the neglect of natural history, the Boston Philosophical Society lasted only a few years. The first permanent organization was the American Philosophical Society, founded in 1769, and absorbing several other groups in Philadelphia, and naming Benjamin Franklin, America's most eminent scientist, as president.[4]

Not to be outdone by Philadelphia, the Boston intellectuals under the leadership of John Adams founded the American Academy of Arts and Sciences in 1780. During the next fifty years many more societies were founded in states, in college and university communities, and in cities.[5] It was in such centers as Boston, New Haven, New York, Philadelphia, Baltimore, Washington, and Charleston that the most important of these organizations were founded. Here were the long established communities, the colleges, the libraries, the theaters, and the music halls. And, most important, perhaps, here was the wealth to support such activities, and from the wealth, the leisure to enjoy intellectual and esthetic pursuits.

As this was true in the East, so it was in the Middle West as population increased. In the cities, as they ceased to be frontier towns and settlements, was reproduced the culture of the urban centers of the older settled parts of the United States. It is not really remarkable, for example, that a Western Museum Society was founded in Cincinnati in 1818, and an Academy of Natural Sciences in St. Louis in 1836, or an Antiquarian and Natural History Society in Little Rock in 1837. It would have been more remarkable if they had not, because each city in its own section of the Middle West was an economic center, and partly because each was an economic center, each was also an intellectual center. Each strove mightily to cease being a rough frontier town, and become a sophisticated urban community. Not all succeeded in doing this at once, but it is the effort put forth that is significant.

So the urge to emulate the cities of the East, which had academies of science as a part of their cultural activities, was a strong influence back of the early scientific organizations of the Middle West. Other powerful influences grew out of the Middle West itself. There men of vision and enterprise saw a vast undeveloped continent with rich natural resources of unknown quantity and quality. Dr. Daniel Drake, a leading

promoter of the Western Museum Society of Cincinnati, wrote in an Address to the People of the Western Country:

> Every citizen of the western country must feel the necessity of a speedy development of our mineral resources. To find beneath our soil an adequate supply of the various minerals which are now imported at an enormous expense, [he meant simply from other parts of the country] must be regarded by all as a matter of first and greatest importance. The Managers [of the Western Museum Society] are anxious to be instrumental in the advancement of this useful work and earnestly solicit the cooperation of the public.[6]

And the Western Academy of Natural Sciences of St. Louis also issued an Address saying, "The geological peculiarities of this country are as yet but slightly known; the immense mineral resources that it possesses also need development, for the little already learned of them justifies the belief that when so developed they will create a new era in the arts and manufactures of the West."[7]

Then, also, in the early nineteenth century, as it had been in the Enlightenment of the eighteenth century, it was a part of the intellectual equipment of men of education and culture to be knowledgeable about natural history. Samuel Morton, Daniel Drake and George Engelmann were the nineteenth century counterparts of Benjamin Franklin, Thomas Jefferson and others who banded together to form the American Philosophical Society.

Finally, there was close association between these natural history societies and academies of science and the members of the medical profession. Partly this was because the doctor was something of a natural scientist through his study of anatomy and materia medica. He also learned something about chemistry, mineralogy and other sciences through his training. What is more, most men attracted to a medical career had well-developed curiosities, and were thus led to inquire into fields related to medicine: the study of plants, for example.

As a result of these factors, academies of science and natural history societies came into existence, but as has been said, these factors were not unique to the Middle West, but were present in the founding of societies in Europe, England, and in the United States. So far as is known, the following societies were founded in the Middle West in the period up to the beginning of the Civil War:

Western Museum Society, Cincinnati	1818
Western Academy of Natural Sciences of Cincinnati	1835
Western Academy of Natural Sciences of St. Louis	1836

Antiquarian and Natural History Society of Arkansas, Little Rock 1837
Cleveland Academy of Natural Science 1845
Society for the Advancement of Natural Science, Louisville 1851
New Orleans Academy of Science 1853
Wisconsin Natural History Association, Milwaukee 1855
Academy of Science of St. Louis. 1856
Chicago Academy of Science 1856
Der Naturhistorische Verein von Wisconsin, Milwaukee . . . 1857
Illinois Natural History Society, Bloomington. 1858

While these societies were being founded, others continued to be founded in the East. For example, in 1818 when the Western Museum Society came into being, the Troy, New York, Lyceum of Natural History came into existence. In 1835 when the Western Academy of Natural Sciences of Cincinnati was organized, one appeared in Hartford, Connecticut.[8]

While the basic factors of urban influence, the desire to discover and describe natural resources, the gentlemanly concern for the advancement of learning, and the inquiring spirit of the doctor-scientist were present in the founding of natural history societies, they were present in different combinations in different situations. These points can be illustrated by looking at the history of some of the Middle Western societies and academies; first, the Western Academy of the Natural Sciences of St. Louis.

Just exactly when or how the idea of a natural history organization first appeared in St. Louis is not known, but it is very possible that one of the influences was the publication by Congress of a report on the geology "of the elevated country between the Missouri and the Red Rivers" by George W. Featherstonhaugh.[9] Featherstonhaugh was an Englishman of independent fortune who came to the United States as a young man, and became interested in scientific and geological matters. In 1834 he made a survey of Missouri and Arkansas under the direction of the War Department and his report was ordered to be printed by both the House and the Senate.[10]

Then, as now, Congressional documents were widely distributed by Congressmen and Senators to their constituents, always including newspaper editors. The Missouri Republican reprinted those parts of the report that described Iron Mountain and other mineral deposits in Missouri, and the Missouri Argus published almost the entire document.[11] Featherstonhaugh was not a very expert geologist by modern standards, but he couldn't miss the most prominent sources of mineral wealth like the iron

and lead ores of Missouri.[12] At least his report aroused the people of the West to want to know more about their natural resources.

Another strong influence on the interest in natural science in St. Louis, as it was in other places, was the American Journal of Science, the leading periodical in the field. That it was read by scientists of the city is shown by the appearance in it of "Meteorological tables for the year 1836, prepared by the Meteorological Department of the St. Louis Association of Natural Sciences."[13] In the American Journal of Science also were the results of public investigations, such as state geological surveys, and personal and private scientific findings.[14]

From the American Journal of Science and from the publications of such organizations as the Academy of Natural Sciences of Philadelphia, and from the personal experience in Europe of George Engelmann and others, the group of natural history enthusiasts in St. Louis would have known what an academy of science was, how it should be organized, and what it should do.[15]

But no organization could even get started without able leaders, and in St. Louis was a group of young doctors, several of whom had been educated in Germany and were already competent scientists. Dr. Engelmann was the sparkplug of the movement, but he was closely seconded by his fellow countryman, Dr. Adolph Wislezenus, and by Dr. Henry King and Dr. Benjamin B. Brown, both American born, who were also enthusiastic and capable scientists.

Beginning sometime in 1835 or 1836, Engelmann, Brown, Wislezenus, the Rev. William G. Eliot, Jr., William Weber, the editor and publisher of the Einzeiger des Westens, and others, held informal meetings in homes and offices, in some such manner as Eliot described when he wrote, "More than forty years ago, five or six young men, of whom I was one, met together on Main Street near Chestnut in the office of the Honorable Mary [Marie] Le Duc."[16] (Le Duc was the judge of the County Court).

The result of these meetings of doctors and public spirited laymen was announced in the press: "The public is respectfully informed that the chemical and mineralogical department of the St. Louis Association of Natural Science will analyze any minerals found in Missouri or the adjoining states, provided they are sent free of charge to the Corresponding Secretary.
P.S. The different newspapers of the mining districts are respectfully requested to publish this.

[signed] B. B. Brown
Cor. Sec'y."[17]

and the editor commented, "We are sure from the character of those composing the society that a perfect reliance may be placed upon them."[18]

Clearly the members of the Association of Natural Science felt that they had an important function to perform, but they soon saw that they needed financial assistance if they were to carry it out successfully. Arguing that they did perform a service of value to the people of the state, an attempt was made to get a subsidy from the legislature. In this they failed, probably because they could not arouse enough backing among the legislators. But on February 6, 1837, the Association of Natural Science did receive recognition under the new name of The Western Academy of Natural Sciences of St. Louis by an Act of Incorporation.[19]

Under the Act of Incorporation, the Academy adopted a constitution, following the pattern established by such organizations as the Academy of Natural Sciences of Philadelphia. Four classes of members were created, officers were to be elected annually, and "departments" were set up, each with a chairman, to direct the activities of the Academy. The departments were Zoology, Botany, Natural Philosophy and Meteorology, Chemistry and Mineralogy, and Geology. Specimens donated to the Academy were to be received and identified by the departments and placed in the museum, which was to be opened to the public. Members were to pay a ten dollar entrance fee and annual membership dues of five dollars.[20]

To bring the Academy before the people, "An Address" was prepared and made public both through a pamphlet published by William Weber[21] and by the newspapers, in which the activities of the Academy and its value to businessmen and investors was pointed out.

The Western Academy of Natural Sciences flourished actively for a few years. It established a museum at "the northeast corner of Fourth and Chestnut streets, upstairs,"[22] and received contributions from Lewis Clark, who deposited some of his father's, William Clark, "scientific collection," and Ed Charles, Colonel John O'Fallon and Captain William Stewart contributed specimens that had been collected in the Far West. The members also deposited parts of their personal collections of bird and animal skins, plants, and geological and mineralogical specimens and books.[23]

Other activities were a report on the discovery of a vein of anthracite coal near Iron Mountain, and information given to Jean Nicollet, a French astronomer and scientist employed by

the War Department to survey and map the Upper Mississippi country. Nicollet spent some days in St. Louis and met with the members several times.[24] And, of course, the individual members continued the study of natural history. Most outstanding was Dr. Engelmann, who, in addition to his own work of collecting and identifying plants, bought specimens from collectors, and distributed them among museums in the United States and in Europe.[25]

The scientific work of these men was quite limited, from a modern viewpoint, since it was almost altogether the collection and identification of specimens. But since so many new plants and other natural history objects were being found in the new country to the west, this taxonomical work was of the greatest importance.

But, aside from these weighty things, the members of the Western Academy of Natural Sciences received personal inspiration from their association with men of like interests. In 1840 Engelmann made a trip East, and sent back a barrel of oysters to his friends. Dr. Brown wrote to thank him, saying:

> You may readily guess my surprise when your communication arrived. . . and to show a proper respect for the documents [he meant the barrel oysters] and also the source from which it emanated, I was not slow in communicating it to the body scientific which caused a general turnout and resulted in the firm resolve that Shorlach Burger [was this a brand of beer?] was the only proper medicine in which sentiment might be embalmed for the occasion and kindred spirits talk the matter over--accordingly six corks were drawn and as many times our wandering friends were cheered. But that barrel of oysters. . .--it's too much to think on.[26]

But, in spite of the interest and enthusiasm of the members, the Western Academy of Natural Sciences ceased to exist as a formal organization about 1843. It did not get the public support it needed, because, as President Henry King had once said, "People are too occupied with the wants of life."[27]

As has been noted, however, the Western Academy of Natural Sciences of St. Louis was only one of several organizations founded in the Middle West in the first half of the nineteenth century. Antedating the St. Louis group by nineteen years was the Western Museum Society of Cincinnati, founded by one of the most dynamic civic leaders of the time, Dr. Daniel Drake, physician, author, businessman and scientist. Drake, born in Kentucky and reared on a pioneer farm, studied medicine with a practicing physician in Cincinnati and then attended the medical school associated with the University of Pennsylvania in Philadelphia.

After a short stay as a member of the medical department of Transylvania University in Lexington, Kentucky, he returned to Cincinnati, where, except for brief periods he made his home for the rest of his life.

During a second visit to Philadelphia in 1815, Drake had been greatly impressed with the museums, colleges, medical schools, and other cultural institutions of the Quaker City, and he believed that Cincinnati, a booming and prosperous river town, should become the cultural center of the Ohio Valley. Drake wrote, in 1816, about Cincinnati in terms that would need little change to describe the St. Louis of the 1830's, when the Western Academy of Natural Sciences was founded. That is what he said:

> Cincinnati continues to advance. This is so strikingly the case, that if you were here, you would perceive in its present aspect, a great contrast with what it had exhibited six years ago. Two steamboats have been completed at this place within the last eight months, and seven more are now on the stocks. The engines for them and all the iron machinery are made at an extensive iron foundry between our old house and the river. The town generally has undergone great alterations. All the principal streets will in a short time be paved. A horse ferry-boat has been built, and greatly facilitates our intercourse with Newport and Covington. Our two old newspapers have been enlarged to imperial size, and a third will be commenced on Tuesday next.[28]

But economic enterprise was not all; the citizens had debating societies, subscription libraries, a college, a hospital, a school of medicine, and a scientific periodical. In such an atmosphere the interest in natural science bloomed, and Drake felt that Cincinnati should have an institution devoted to it. He had as his model the city of Philadelphia which had all these things.[29]

Drake and his friends, therefore, organized the Western Museum Society in 1818. It grew rapidly and in two years had an exhibit room at Cincinnati College in which was displayed natural history objects and "philosophical apparatus" valued at $4,000. By 1823 the museum had

> 100 mammoth and Arctic elephant bones, 50 Megalonyx bones, 33 quadrupeds, 500 birds, 200 fishes, 5,000 invertebrates, 1,000 fossils, 3,500 minerals, 325 botanical specimens, 3,125 medals and tokens, 150 Egyptian and 215 American antiquities, 112 microscopical designs, views of American scenery and buildings, a tattooed head of a New Zealand chief, and about 500 miscellaneous specimens of the fine arts and an elegant organ.[30]

Museum activities were directed by curators. John James Audubon served briefly in 1819-1820; Robert Best, later a well-known chemist, was another; and a third was Joseph Dorfeulle, a wandering French naturalist of uncertain antecedents. When the Western Museum Society finally folded, Dorfeulle took over the exhibits and showed them along with his examples of antiquities, natural curiosities, and wax figures in a popular museum that flourished in Cincinnati for some years.

The Western Museum Society was active for but a few years, and never reached the goals set for it by Drake. His personal interest flagged when he became involved with the organization and promotion of the Medical College of Ohio, fought a losing battle for control, and left Cincinnati for Lexington. The business decline that began in the East in 1819 hit Cincinnati about 1821, and Drake and others suffered financial reverses. Cincinnati College was affected, too, and in 1825 had to close for a time. All these things together cut short a promising, if overly ambitious, endeavor, and it was not for a decade that another attempt was made.

By that time--1835--business was booming again. Dr. Drake was back in Cincinnati and was once again its chief booster. The city now had a population of 35,000 with an annual business of $6,000,000. It had ten grammar schools, a new church, and two banking houses. One hundred and fifty "handsome private dwellings" had been erected within the year. Its inhabitants could read four daily and six weekly newspapers. Most important of several periodicals was James Hall's Western Monthly Magazine and Daniel Drake's Western Journal of the Medical and Physical Sciences. Cincinnati College had been revived in 1834, and in 1835, a medical department had been inaugurated by Dr. Drake. Also the Medical College of Ohio was flourishing, a hospital was in operation, and there were many physicians engaged in private practice and as teachers in the medical schools. A lyceum, an Atheneum, a College of Teachers, and a Workingmen's Institute were enthusiastically attended, and Lyman Beecher and Harriet Beecher Stowe had begun their educational and literary work.

It was under these conditions that Dr. Drake and others organized the Western Academy of Natural Sciences,[31] and the first meeting was held in the Hall of the Medical Society on April 25, 1835. There were present twenty-one men, eleven of whom were doctors. Of the other ten, three were merchants, one was a manufacturer, two were newspaper and magazine editors, one was the registrar of the United States Land Office, and four cannot be identified.

The man elected president was Robert Buchanan, representative of the type of man so often found leading community activities. He was the businessman who had attained financial security so that he could afford an avocation, and he had adopted natural history as his hobby. His interest in and patronage of natural science brought him not only the presidency of the Academy of Natural Sciences, but also of the Horticultural Society, the Astronomical Society and the Angling Club. He contributed to the financial support of the Academy, and undoubtedly to other scientific organizations as well. His personal knowledge of natural science was sincere and persistent. In 1834 he had made a collection of the flora of Cincinnati, and he gathered shells and fossils, maintaining his own cabinets and exchanging specimens with other naturalists. Later he became interested in horticulture, especially viniculture, publishing a book on the subject.

As noted above, the St. Louis Western Academy of the Natural Sciences died, but the Cincinnati Academy, although it had its ups and downs, kept going until the Civil War, and finally, like the St. Louis Academy, passed its possessions on to a successor organization. It never published a regular series of transactions as did the later Academy of Science of St. Louis, but it sponsored occasional publications, among them a comprehensive list of the flora of the Cincinnati area, and several of its members published articles in national periodicals. In 1851 the Academy joined other local groups in entertaining the American Association for the Advancement of Science. At other times, scientists who came to Cincinnati met with the members, and were conducted to sites of scientific interest.

The Cincinnati Academy maintained a museum, but it was never very well arranged, nor was it always open to the public, because the Academy could not afford to employ a professional curator, and because no suitable hall could be obtained.

Like the St. Louis Western Academy of the Natural Sciences, the organization brought together men of kindred interests, and each received the stimulus of the group association, and felt encouraged to proceed with his own work. At a typical meeting in 1841 in rooms over the fire-house, various members read reports on the craniums of turtles, oriental beans, fossils found in coal, and a cast of a beaver dam found in digging the Ohio Canal. The only matter of business discussed was how to get the money to equip their newly acquired rooms in the Mechanics Institute building. The meeting adjourned abruptly when the fire alarm sounded, and the members left to follow the engine to the fire!

Although the Western Academy of Sciences was an important cultural and scientific influence in Cincinnati and the Middle West, it had become moribund by the late 50's. It had never been on a sound financial basis; its membership was small; its scientific interests were narrow, being largely, especially in later years, confined to paleontology and conchology; and most of its members were without professional training, being little more than self-taught collectors. As has been said, the latter was characteristic of many nineteenth century naturalists. It was a time when the major scientific effort was in collection, description and classification; but by the 1850's these ends had been pretty well met, and the amateurs of the Cincinnati Academy were not equipped for more advanced scientific work. More and more, as the nineteenth century wore on, natural science, along with other branches of science, became specialized and professionalized, and there was less and less room for the mere collector.

As the study of natural science thus passed from the hands of the amateur to those of the professional scholar, the place of the Cincinnati Academy in the cultural life of the city was narrowed to providing a natural history museum for the education and instruction of the public. Since the Academy did not have funds for this, and since its formal organization had fallen apart, it remained for a few interested members, in cooperation with other civic leaders, not especially personally interested in natural history, to found the Cincinnati Society of Natural History in 1871. The major purpose of this organization was to maintain a public museum and carry on a publication program. After a short time the latter was abandoned except for purposes of popular education, and the museum became the principal activity.

Two other early natural history organizations were founded at Little Rock, Arkansas, and Cleveland, Ohio. The Antiquarian and Natural History Society of Arkansas was organized in 1837, and, although Little Rock was a prosperous city, it was oriented to an agrarian economy rather than to commerce and industry, and while there were a few doctors and other men with an interest in natural history, there were too few. Neither was there a medical school nor a college, and the attempts to organize cultural activities like lyceums, circulating libraries, or debating societies were short lived. The Little Rock organization, therefore, had only a fitful existence of some five years.[32]

The Cleveland Academy of Natural Science was organized in 1845 and lived until 1859.[33] Like other societies it was a part of the cultural growth of the city. Its most active members were professors at the Cleveland Medical College and the doctors

of the city. The organization got off to a good start, and soon had over a hundred members. It had quarters at the Medical College, and there it maintained a museum open to the public.

The leading member was Dr. Jared P. Kirtland, a teacher at the medical school, and when the museum was forced to close for lack of funds, meetings continued to be held in his laboratory. Over the span of life of the Cleveland Academy, a variety of papers on natural history were given by Dr. Kirtland, Dr. John S. Newberry, and Colonel Charles Whittlesey--all men of national reputation as geologists and natural scientists. Science enthusiasts among the city's physicians and business men also read papers.

Many of the papers appeared in the short-lived Cleveland publication, the Annals of Science, in the newspapers, and in the Ohio Farmer, the agricultural periodical of which John Kirkpatrick, long-time secretary of the Academy, was editor.

While the museum of the Academy was closed to the public, specimens of all kinds continued to be received and were displayed in a room open to members of the Academy and to the students and faculty of Western Reserve College, with which the medical school was affiliated.

The Academy of Natural Science of Cleveland disappeared about 1859, but it had served a useful local purpose. The stresses of the Civil War, the lack of money with which to broaden either the museum or the publication program, the transfer of Western Reserve College from Hudson to Cleveland all meant that increasingly scientific activity would be the concern of the professional.

The last two societies that will be discussed are the Academies of Science of St. Louis[34] and Chicago,[35] both founded in 1856 and both still active a century later. The period of the 1850's was one of economic prosperity and national expansion. The continental area of the United States had been extended to the Pacific and the present boundaries with Canada and Mexico had been agreed upon. The California gold rush continued. Domestic manufacturing developed rapidly, the iron and steel industry got firmly on its feet, and the West was explored to determine the best routes for transcontinental railroads.

Both St. Louis and Chicago were key points in these operations. Both had developed industry and had become flourishing markets for the distribution of all kinds of commodities throughout the water systems upon which they were located, and they could now look forward to becoming the entry ports to the

western United States. Both were confident that they were on the edge of a great boom that would develop with the construction of the transcontinental railroads. They would have to wait fifteen years for this to be realized, but neither knew this in 1856.

Both cities had many wealthy men, and many more would make their fortunes in the years to come. In both cities all kinds of cultural activities--theaters, libraries, music, art--were patronized by these men. Both cities were centers of medical education, and both had colleges, later to become great universities. So, in both St. Louis and Chicago, the conditions were ripe for founding institutions for the cultivation of science.

Both academies founded in 1856 had local men of standing in various fields of science who gave technical leadership by preparing papers that were read at the meetings, and by collecting specimens and arranging adequate museums. And what is more, there was enough money to acquire permanent buildings to house these museums, and to publish the papers read at the meetings in annual volumes of Transactions that were exchanged for those of scientific organizations both in the United States and throughout the world, thus assuring the authors of appreciative audiences, and at the same time building valuable libraries for both Academies.

The museums of both organizations were open to the public. In heavy walnut and mahogany cases with plate glass tops and fronts, were arranged orderly and scientifically classified collections of flora and fauna, both fossil and living types, as well as "suites" of minerals and rocks. To the modern director these museums were little more than mausoleums, because this was the age of the stuffed bird on the wooden perch, the toothy bear, and the snarling wildcat. In one corner was sure to be a meteorite of some size, and in another a gigantic specimen of rock crystal, and always there was a case of Indian arrow heads arranged in symmetrical patterns. And yet, dull as these museums seem to us today, they served a cultural purpose, since they offered study collections to earnest amateur scientists or collectors, as well as to the growing number of professionals connected with the colleges. To the layman who visited the museum was revealed a marvelous ordered world of nature, of which he was only dimly aware in his daily concern with making a living.

The Chicago Academy had much more money with which to operate than did the St. Louis Academy. As a result, Chicago had specially constructed and equipped buildings, while St. Louis had to be content with rooms or converted mansions. But

St. Louis had a more distinguished publication than did Chicago. Both organizations suffered ups and downs of attendance at meetings, and both organizations experienced disastrous fires.

As time went on, the scope of activity of both Academies was narrowed. In Chicago the great Field Museum of Natural History was built, and later the Museum of Science and Industry was financed by the Rosenwald millions. Although much handicapped by meager funds, the Academy has continued to serve the city. In its location in Lincoln Park near the Zoo, and near the Chicago Historical Society, it is part of a complex of agencies for popular education. It has concentrated its efforts on the natural history of the Chicago area, and has collected all kinds of material to illustrate this, and it has sponsored research in this field. In recent years it has, however, directed its attention to science for children.

The St. Louis Academy, too, has been hampered by lack of funds. On a number of occasions valiant efforts have been made to arouse civic consciousness to the great value of a natural history and science and industry museum. These efforts have had some small success, and over the years the Academy has received several tens of thousands of dollars, which have been carefully conserved as endowment funds. The Academy has also a long list of individual and institutional members who pay annual dues.

Today, in the middle of the twentieth century, the Academy conceives its purpose to be an agency for popular education about science. Strongly organized as it is, and with money in the bank, the St. Louis Academy of Science is ready and waiting to move into its next stage of usefulness to the community as sponsor of a proper museum, as have the Academies of Chicago, Cincinnati, and Cleveland. Thus the academy of science in its new life as a public museum, is still an important part of the culture of the city.

FOOTNOTES

[1] See Ralph S. Bates, Scientific Societies in the United States (New York and London, 1945), 1-2.

[2] See Dorothy Stimson, Science and Amateurs, A History of the Royal Society (New York, 1948).

[3] Bates, 2-3.

[4] Bates, 7-8.

[5] See Max Meisel, Bibliography of American Natural History: The Pioneer Century, 1769-1865 (Brooklyn, New York, 1926), II, for a list of these and other institutions. See also Bates, 20-84, passim.

[6] American Journal of Science, I (1818), 203-204.

[7] Act of Incorporation, Constitution and By Laws of the Western Academy of Natural Sciences (St. Louis, 1837), 14.

[8] See Meisel, II, xi; III, ix; Bates, 51.

[9] Geological Report of An Examination Made in 1834, of the Elevated Country between the Missouri and Red Rivers. Washington, Gales and Seaton, 1835. U. S. 23 Cong., 2 Sess., H. Doc., v. 4, No. 513, Ser. No. 274. Also 23 Cong., 2 Sess., Sen. Doc., v. 4, No. 153, Ser. No. 269.

[10] See George P. Merrill, One Hundred Years of American Geology (New Haven, 1924), 136-138, 161-165.

[11] Missouri Republican, March 6, 1836; Missouri Argus, September 11, 25, 1836. It was printed in other western newspapers, as in Arkansas Gazette, July 21, 28; August 25; September 1, 1835.

[12] Merrill, 136-138, 161-165.

[13] XXXII (1837), 386.

[14] See Meisel, II, 275-387 for a list of the articles in American Journal of Science. See also Merrill, 127-208, passim.

[15] As a boy of fourteen, George Engelmann had attended the meetings of the Senkenberg Society of Natural History of Frankfort am Main. William G. Bek, "George Engelmann, Man of Science," in Missouri Historical Review, XXIII, (1929), 168.

[16] Quoted by Mary J. Klem in "The History of Science in St. Louis," in Academy of Science of St. Louis, Transactions, XXIII (1914), 11.

[17] Missouri Republican, January 13, 1837.

[18] Missouri Republican, January 13, 1837.

[19] An Act of Incorporation, etc.

[20] An Act of Incorporation, etc.

[21] An Act of Incorporation, etc., 13-18; Anzeiger des Westens, September 2, 1837.

[22] St. Louis City Directory, 1842, p. VII.

[23] "Annual Address of the President of the Western Academy of Natural Sciences at St. Louis, Mo. Delivered in the Hall of the Academy, the 16th of January, 1838," in Missouri Saturday News, February 10, 1838.

[24] Jean Nicollet to George Engelmann, Riviere Ohio, Steamboat Maryland, November 27, 1837. Engelmann Letters in Missouri Botanical Gardens; Merrill, 153.

[25] Engelmann Letters, passim.

[26] Engelmann Letters.

[27] "Annual Address, etc.," in Missouri Saturday News, February 10, 1838.

[28] Edward D. Mansfield, Memoirs of the Life and Services of Daniel Drake, M. D. (Cincinnati, 1855), 131.

[29] For the full story of the Western Museum Society see Walter B. Hendrickson, "The Western Museum Society of Cincinnati," in The Scientific Monthly, LXIII (1946), 66-72.

[30] C. T. Greve, Centennial History of Cincinnati (Cincinnati, 1904), I, 523.

[31] For the full story of the Western Academy of Natural Sciences, see Walter B. Hendrickson, "The Western Academy of Natural Sciences of Cincinnati," in Isis XXXVII, (1947), 138-145.

[32] See Myra McAlmont Vaughan, "The First Historical Society of Arkansas," in Arkansas Historical Association, Publications, II (1908), 346-353. This account is supplemented, and corrected in many ways, by an article by Walter B. Hendrickson, "Culture in Early Arkansas: The Antiquarian and Natural History Society of Little Rock," in the March, 1958 number of the Arkansas Historical Quarterly.

[33] For an account of the Cleveland Academy see Proceedings of the Cleveland Academy of Natural Science, 1845-1859 (Cleveland, 1874).

[34] See Frederick Starr, "The Academy of Natural Science of St. Louis," in The Popular Science Monthly, LII (1898), 629-647; William Trelease, "The Academy of Science of St. Louis: A Biography," in The Popular Science Monthly LXIV (1903), 117-130. Henry M. Whelpley,"A Sketch of the History of the Academy," in Academy of Science of St. Louis, Transactions, XVI (1906), xxi-xxxii.

[35] For an account of the Chicago Academy, see William K. Higley, "Historical Sketch of the Academy," in Chicago Academy of Science, Special Publication, Number 1 (Chicago, 1902).